COMPARISON OF LEED TO NON-LEED CERTIFIED HOSPITALS WITH REGARDS TO PATIENT PERSPECTIVE AND FINANCIAL INDICATORS

A Thesis

by

EREN ULUSOY

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2012

Major Subject: Civil Engineering

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Approved by:

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Ivan Damnjanovic
Committee Member, Andrew Johnson
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ABSTRACT

Comparison of LEED to Non-LEED Certified Hospitals with Regards to Patient Perspective and Financial Indicators. (August 2012)

Eren Ulusoy, B.S., Istanbul Technical University

Co-Chairs of Advisory Committee: Dr. John Walewski
Dr. Ivan Damnjanovic

As natural resources are decreasing and environmental pollution is increasing, the buildings that play an important role in this problem should be constructed sustainably so their affects are kept to a minimum. Hospitals operate 24 hours a day and 7 days a week, therefore they are one of the largest energy consumers. Hence designers have started to design healthcare facilities according to the Leadership in Energy and Environmental Design (LEED) criteria, believing that it will reduce waste production, energy consumption and increase patient satisfaction by creating brighter and less stressful facilities. To understand if the claims are correct or not, this thesis first studied the results of the patient survey, Hospital Consumer Assessment of Healthcare Providers and System (HCAHPS), undertaken at most of the hospitals in the U.S., and compares the results to LEED and non-LEED certified hospitals. To find answers for the claims related to the financial benefits, this thesis compared three financial indicators; cost of operation of plant, profitability, and inpatient revenue. In the cases where there is a large enough sample size, a t-test is used to compare two groups, however when the sample size was not large enough, two groups are compared based on their means.

For the cost of operation of plant and profitability, non-LEED certified hospitals are performing better. However, the patient satisfaction and inpatient revenues are significantly higher at the LEED-certified hospitals.

DEDICATION

This thesis is dedicated to my parents who allowed me to attend Texas A&M University which is far from my home country where they live and never rejected whenever I needed something from them. Also I want to thank my God who gave me the power to complete this task successfully.

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NOMENCLATURE

AHD	American Hospital Directory
CMS	Center for Medicare & Medicaid Services
HCAHPS	Hospital Consumer Assessment of Healthcare Providers and System
LEED	Leadership in Energy and Environmental Design

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1. INTRODUCTION

Healthcare facilities are major energy consumers and require the use of hazardous and toxic chemicals and materials. Therefore new hospitals are now commonly designed with regards to such concerns and high-level goals include energy consumption efficiency, minimization of toxic materials, and methods and practices to improve patient/staff health or satisfaction by providing a healthier environment. According to previous measurements, U.S. healthcare facilities are the second largest cause of carbon dioxide pollution, which leads to global warming (Joseph et al. 2010). In 2003, hospitals were making a 9 percent contribution to the total energy consumption in the U.S., a significant level of consumption when compared to the other sector (EIA 2011). Figure 1.1 shows the rank of healthcare facilities with other building types regarding total amount of energy consumption.

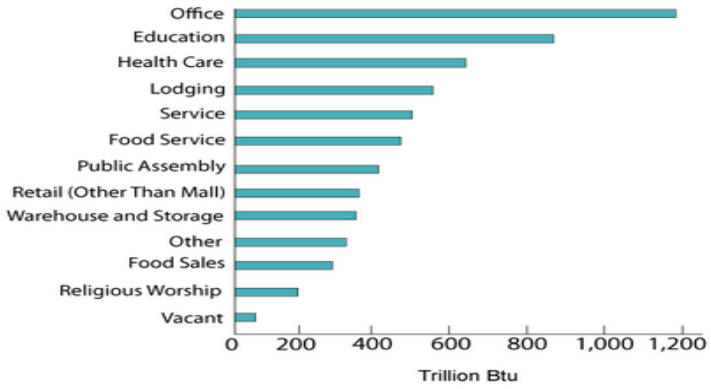

Figure 1.1 Energy Use by Type of Commercial Building, 2003(EIA 2011)

This thesis follows the style of *Journal of Construction Engineering and Management.*

Designers have been looking for reasonable solutions to these problems without decreasing the customer satisfaction. For the healthcare facilities, Leadership in Energy and Environmental Design (LEED) and Evidence Based Design can be shown as some of the approaches to deal with these issues. In general, these features help to create an environment that is less stressful for the both the patients and the staff, improve productivity, motivate staff while doing their job, and help satisfy the customer with the offered services. Recent researches show that healthcare design can increase the quality of patient care and medical outcomes by reducing the medical errors or waste (Guenther and Vittori 2007).

Another aspect of the impacts of sustainable design for hospitals is the difference in financial indicators compared to the non-sustainable designed ones. LEED certified hospitals may cost more to construct than the non-LEED hospitals, and the difference between these costs may have to be compensated by patients' income, operation and maintenance cost or other financial factors. There are few studies regarding the cost and benefits of hospitals pursuing LEED certification. Most of the researches are documenting the financial benefits of LEED for commercial or similar facilities. For example, in 2005 a paper prepared for the U.S. Green Building Council (USGBC), investigated 25 office buildings and 8 schools constructed between 1995 and 2004, and claimed "The additional first costs associated with green buildings are about 2%, while the financial benefits are about 10 timed as large" (Wilhelm 2005). Whereas sustainable building has been found to be cost-effective for many building types when compared to sector-specific metrics (Wilhelm 2005), minimal such documentation exists for the

healthcare sector. Based on these initial findings, the focus of this thesis is an analysis of LEED achievement status with industry specific performance metrics.

2. PROBLEM DESCRIPTION

2.1 Thesis Statement

The main focus of this thesis is to compare LEED-certified hospitals and non-LEED certified ones against financial metrics such as operation of plant costs, patient revenue, and profitability.

The problems this thesis focuses on are:

- Comparison of LEED-certified hospitals with non-LEED projects with regards to patients' perspective of healthcare
- Comparison of hospitals with regards to operating expenses
- Comparison of hospitals by their patient revenue
- Identify potential relationships between hospitals with different levels of LEED certification (Platinum, Gold, Silver or Certified) and their financial indicators like patient revenue or operating expenses.

Hypothesis 1:

Is the patient satisfaction significantly higher at the LEED certified hospitals compared to non-LEED certified ones?

Source of Data - Hospital Consumer Assessment of Healthcare Provider and Systems (HCAHPS)

Method – There are four options to answer each question which are 'always', 'usually' 'sometimes' and 'never'. However 'sometimes' and 'never' are grouped in one column in the database, so this leaves three options. 'Always" is assumed to be a positive score, 'usually' is neutral and 'sometimes/never' is negative. To calculate the score of the hospital for each question, the percent of 'sometimes/never' is subtracted

from the percent of ‘always’ and then these number are summed up and divided to the total number of facilities to find the mean score of LEED certified and non-LEED hospitals. All the means are then compared by using the t-test.

Hypothesis 2:

Is it more economical to operate a LEED certified hospital compared to non-LEED certified hospitals?

Hypothesis 3:

Are the LEED certified hospitals more profitable than the non-LEED certified ones?

Hypothesis 4:

Are the financial indicators like operation of plant expenses, total operating expenses, or patient revenues providing better values with the increased level of LEED certification?

The source for hypothesis 2, 3 and 4 is American Hospital Directory (AHD) and Center for Medicare &Medicaid Services (CMS)

The methods applied to compare the results of these three questions are comparison of the means and t-test (if applicable).

2.2 Methodology

Hospitals are going to be compared based on patient satisfaction and financial indicators. Two different sources of data are needed. The one for the patients’ perspective will be obtained from a survey which is a common evaluation form used in all of the hospitals and basically lets the patients evaluate the hospital and the service offered at the hospital. This survey is called Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) and the database related to the survey can be downloaded from

http://www.medicare.gov/Download/DownloaddbInterim.asp. Some of the questions of the survey will be considered in the thesis for comparison of hospitals, and they are listed below. The rest of the survey can be found in the Appendix A.

- Would patients recommend the hospital to friends and family?
- How do patients rate the hospital overall?
- How often was the area around patients rooms kept quiet at night?
- How often were patients' bathrooms kept clean?
- How often did staff explain about medicines before giving them to patients?
- How often was patients' pain well controlled?
- How often did patients receive help quickly from hospital staff?
- How often did doctors communicate well with patients?
- How often did nurse communicate well with patients?

LEED-certified hospitals will be extracted from the USGBC LEED directory which contains 43,632 LEED-certified projects. Out of these 43,632 projects, 114 of them are hospitals that will be searched in the HCAHPS survey database. The HCAHPS survey is applied by 4,488 hospitals and 32 of these hospitals are listed in the LEED directory. Therefore in this thesis, the author will compare the survey results between 4,488 non-LEED certified hospitals and 32 LEED-certified projects. However after downloading the database, it was noticed that some of the hospitals wanted to keep their results confidential, so there was a need to crop the data where the results were reflected as 'N/A'. After cropping those lines, the total number of hospitals which will be compared was reduced to 3,533 non-LEED certified hospitals. Based on the outcomes obtained

from this comparison, the question “Is there a significant difference between LEED certified and non-LEED certified hospital regarding the patient satisfaction?” will be explored. To analyze the data in hand, a t-test procedure across the nine criteria listed above will be used.

For the comparison of financial indicators, the database used is different than the previous one, because the survey does not contain any questions regarding patient revenue or other financial measurements. This time the data will be extracted from two websites. One of them is the American Hospital Directory (AHD) that has financial information about more than 6,000 hospitals located in U.S. The AHD database provides cost data related to general services, O&M, etc. for each hospital registered to that website. The second one is the website of Centers for Medicare & Medicaid Services (CMS) that contains all the cost reports of the hospitals. These cost reports are incorporating every single data like square footage, number of employees, operating expenses, patient revenues, etc. of the health care facilities.

As mentioned, there are 114 LEED certified hospitals in the U.S.; however 53 LEED certified hospitals’ data could be found by using the AHD and CMS database. 15 of these 53 hospitals are having LEED certificate for the whole structure, but the rest has it only for some departments of the hospital. Therefore the hospitals which have the whole building LEED-certified are going to be analyzed separately, and also there will be other comparisons based on the different criteria mentioned in section 4.2.1. Depending on the sample sizes in some cases t-test will be applied, but for the ones with less than 30 samples the comparison is going to be the comparison of the means.

To find a reasonable answer to the last hypothesis, additional criteria will be considered. As mentioned, there are four LEED certification levels; Platinum, Gold, Silver, and Certified. Out of 114 LEED-certified hospitals 3 of them have Platinum designation, 34 have received Gold designation, 33 have achieved Silver designation and 40 of them only have a LEED certificate. 4 of them are still being reviewed. To have more accurate comparison, only Gold, Silver and Certified levels will be considered, because the sample size for Platinum is only three and it is not reasonable to run a test for a group of three.

3. BACKGROUND AND LITERATURE REVIEW

The main scope of this section is to provide information about the concepts of LEED and Evidence Based Design and then relate the literature to thesis topics. It is very common to find articles that discuss the cons/pros of sustainable design for hospitals, however there is not much research that documents the impact of these design on patient satisfaction and financial indicators. Therefore, this thesis attempts to fill this gap as much as it can.

3.1 History of Green Building

This subsection includes a brief introduction about the meaning of the green building, its evolution, and some details about the barriers to sustainable hospital design.

3.1.1 Definition and Evolution of Green Building

"The Office of the Federal Environmental Executive defines green building as the practice of:

1) increasing the efficiency with which buildings and their sites use energy, water, and materials

2) reducing building impacts on human health and the environment through better siting, design, construction, operation, maintenance and removal the complete building life cycle"(Cassidy 2003).

Because of reasons such as the price of oil increasing dramatically, the quality of outdoor environment decreasing, and the need for energy efficient buildings, architects started to think of new design techniques where the buildings consume less energy and pollute less. In 1972, American Institute of Architects energy committee was formed,

and couple of years later they created one of the first environmental references for architects. After two decades, it was understood that this committee was not enough to deal with all of the sustainable design problems, therefore they started a new organization called U.S. Green Building Council (USGBC) in 1993(Roberts 2011).

Then, USGBC published some criteria to measure the degree of sustainability of the buildings which is known as Leadership in Energy and Environmental Design version 1.0. After applying these criteria to 12 buildings, USGBC came up with the new version of LEED called version 2.0 (Roberts 2011). This concept will be defined in more detail in section 3.2.

In addition to this, there are other organizations to encourage green building. Below there are three examples from these organizations (Hampton 2007).

- *The Green Guide for Healthcare*: Developed by Healthcare Without Harm and the Center for Maximum Potential Building Systems, this document let the designers know how to incorporate environmental practices into design, construction, operation and maintenance of healthcare facilities. (http://www.gghc.org/)

- *Healthcare Without Harm*: Their aim is to decrease the pollution in the healthcare industry. (http://www.noharm.org)

- *Hospitals for a Healthy Environment*: Their role is to train healthcare professionals about environmental friendly practices and reduction of pollution. (http://www.h2e-online.org/)

3.1.2 Barriers to Green Healthcare Facilities

Even though designers and architects are trying to design the Healthcare Facilities as "green" as possible, there are some conditions which keeps them from having a facility with an optimum efficiency level. Hospitals are places which operate 24 hours a day, 7 days a week and they are usually occupied with many patients, visitors and staff at the

same time. All these people need a comfortable, less stressful and healthier environment. To accomplish these, the lighting, indoor environmental quality, patient rooms, restrooms etc. have to be optimized for their use by requiring the use of many chemical materials for cleaning, large deal of electric consumption or huge amount of waste production. Below there is a list of all of the barriers to green health facilities (Roberts 2011).

- *"System Redundancy"*: The backup systems have to be able operate even if there is an emergency situation.
- *"Regulatory Compliance"*: All the safety regulations and building codes prevent the facility from being green.
- *"Operational Hours"*: They need to operate 24 hours a day, 365 days a year.
- *"Infection Control"*: Hospitals are places where there is need of severe infection controls.
- *"Ventilation Rates"*: Hospitals are huge facilities, and their ventilation rates can be 1.5 to 3 times greater than any other commercial building.
- *"Intense Energy and Water Use"*: According to the previous researches hospitals consume 2.1 times more energy per square foot than other commercial buildings and they use 80-150 gallons of water per bed per day (ROBERTS 2011).
- *"High Volume Waste Stream"*: Hospitals transfer 6,600 tons of solid waste each day to landfills.
- *"Chemical Use"*: Harmful chemicals need to be used to sterilize the environment and equipment.
- "*Life Cycle"*: Even though the facilities are designed to last for long years, the interior structures have to be renovated more frequently.

3.2 Sustainable Design (SD) and Leadership in Energy and Environmental Design (LEED)

Sustainable design is a design specification which includes natural environmental factors into the structure designs to take advantage of some of the natural resources such as sunlight, wind patterns, and geographical location to reduce the impact of the building on global environment (Ecomii 2012). With the sustainable design, the scope is to eliminate the negative effects of the buildings on the environment and to obtain the maximum efficiency from the structure by consuming less energy, by using renewable energy sources, by water conservation, by recycling the waste products or by using non-toxic products (Ecomii 2012). Sustainable design procedure should be considered from the beginning of the designing process for having the full efficiency from the structure.

When it comes to hospitals, the main reasons of applying sustainable design are to;

- provide a better indoor air quality and allow the daylight pass through large windows to keep the building bright.
- save money by having an energy management and waste management plan, and conserving water.
- reduce the impact of the building on the environment to a minimum level and provide a healthier environment for the people (Buckley and Smyth 2007).

As mentioned in section 3.1.1., in the United States and in some of the countries around the world, there is a certification system which is used to certify structures that are constructed based on the sustainable design principles and these structures are also called as “Green Buildings”. Leadership in Energy and Environmental Design (LEED) is the name of this certification system and it is administrated by the U.S Green Building

Council (USGBC) (NRDC 2011). “LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and health:

- Sustainable site development
- Water savings
- Energy efficiency
- Material selection
- Indoor environmental quality” (Buffaloe 2009)

LEED-certified buildings have to have low operating costs, produce less waste material, conserve energy and water, provide a healthier environment for people and have less gas emissions (USGBC 2011).

There are four types of certification depending on the scores that the structure gets out of 100 which is the maximum score (Buffaloe 2009).

- Minimum points: Certified
- Second highest points: Silver
- Third highest points: Gold
- Maximum Points: Platinum

As mentioned earlier, hospitals are going to be compared based on their certification level, too.

3.3 Evidence-Based Design (EBD)

Evidence Based Design is a term which is used for hospitals and it represents the design procedures to maximize the patients’ satisfaction about the hospitals. According to the research that has been done within the last few years, there are many evidences about the

fact that physical environment affects patient stress, patient and staff safety, staff effectiveness and quality of care offered at the hospitals (Saint Alphonsus 2011). "Therefore hospital designers and owner keep in mind couple of factors such as;

- Single patient rooms
- Installing HEPA filters
- Providing access to nature
- Installing ceiling lifts
- Installing sound-absorbing ceiling tiles
- Family areas within patient care spaces
- Providing access to sunlight
- Promoting the use of visible and accessible hand washing dispensers
- Promote visual access and accessibility to patient
- Providing areas of respite for staff." (Saint Alphonsus 2011)

These are beneficial not only for patient and staff satisfaction, but also they help to keep them healthy by reducing the chance of diffusion of viruses or infections within the people in the hospital. Moreover, it can be seen that some of these features are common with the sustainable design specifications. Therefore in the next part, a summary of a study that has been completed by a group of researches to understand how the Sustainable Design and Evidence Based Design are common at some points is provided.

3.4 The Intersection of EBD and SD

Even though these two terms are considered to be different in some ways than the other, they are actually intersecting. According to the SD, buildings have to maximize the

ecological health and indoor environmental quality; however EBD is focusing on the health outcome by using some applications offered by the researchers. Some people claim that these theories are in conflict, because for example to have a healthier environment at the hospital, people have to wash their hands more, but the hand washing procedure is not something appreciated by the sustainable designers because of water consumption. Another example of the conflict between two designs can be the use HEPA which is an electrical device used to control infection, because it causes the building consume more energy (Rostenberg 2011).

In the research titled "The Intersection of Evidence-Based Design and Sustainability" (Rostenberg 2011) the team selected nine EBD and nine SD hospitals and they let the healthcare administrators who are working at those hospitals complete a survey to evaluate their own facilities with respect to SD features and EBD features. According to the results obtained from the survey there are many common features between SD and EBD. One of them is the elimination/recycling of waste materials which is both healthier for environment and the patient/staff. Another one is the access to nature, which helps the patient/staff have fresh air whenever they need or whenever they feel stressed. Linoleum flooring and daylight harvesting are other strategies which are both wanted for SD and EBD, in such a way that linoleum is a material produced from natural materials making it environmental friendly and healthy for the patients. In addition, daylight harvesting keeps inside of the building bright by causing less energy consumption and letting the patients to have a less dark indoor environment. Other than these strategies optimal size for the hospital is a concern for both SD and EBD, because

the facility has to be small enough to be environmental friendly and to spend less energy; however it also has to be big enough for the future needs where the patients might be using for other services. Both of the SD and the EBD have to be considered from the beginning of the designing process to achieve the maximum efficiency.

These being said, even though SD and EBD have many specifications in common or in contrary that would affect the patient satisfaction and financial indicators, EBD is not part of this thesis.

3.5 Sustainable Features Used in Hospital Design

There are different kinds of practices in the hospitals to provide a sustainable environment and to get the LEED certification. Most important and most common methods used are listed below.

3.5.1 Waste Management and Toxic Materials

Even though hospitals are producing large amount of waste which have a very harmful effect on the environment, most of them do not recognize this fact. They usually keep on wasting money to dispose the generated waste to landfills resulting in damage to the environment. Such organizations are in need of a well prepared waste management system that is highly cost effective and environmental friendly. Executive Director of the organization "Hospitals for a Healthy Environment" claims that the health care facilities which apply the program created by this organization come up with significant amount of money savings (Hampton 2007).

There are several types of waste generated by the health care facilities. These are listed below and the percentage breakdown of some of these wastes can be found in Figure 3.1.

- "Hazardous waste
    - Batteries
    - Fluorescent light tubes
    - Formaldehyde and Formalin
    - Mercury
    - Computers and Equipment
    - Solvents
- Chemotherapy waste
- Pharmaceutical waste
- Radioactive waste
- Medical waste
- Solid waste" (Badrick 2010)

Figure 3.1 Typical Hospital Waste Profile (Badrick 2010)

Previously, these wastes were usually burned in incinerators; however researchers discovered such incineration were very harmful to environment. Therefore, since 1995 use of these were regulated to decrease the impact. Then recycling the waste started to become more popular. Some of the above listed wastes can be recycled or re-used. The recyclable ones are paper and cardboards, plastics, metals, glasses and sharp containers, whereas surgical instruments and tools, basins, containers, linens such as bedding, scrubs and gowns can be re-used after some modifications (Badrick 2010). Effectively managed hospital waste profile is reflected in Figure 3.2

Figure 3.2 Effectively Managed Hospital Waste Profile (Badrick 2010)

In an interview made with Mark Lennon, Principal, Institution Recycling Network, he claims that there are some practices which would motivate the health care facility administrators to apply a waste management plan, because they could make money out

of this. For example, hospitals are using almost tons of paper every day and if they start to recycle these waste papers they can gain $200-300 dollar per ton of waste paper by collecting a large amount of money each year. Additionally, they can also recycle the used plastic which is valued as couple of cents per pound of plastic (Lennon 2010).

In many cases the hospital staff is getting rid of the waste by just throwing it away into trash, and the hospital needs to pay money for disinfection and disposal. According to "Hospitals for a Healthy Environment" health care facilities can save up to 40-70% on their disposal expenditures by just decreasing the amount of regulated waste (Hampton 2007).

University of Michigan, Hospitals and Health Centers, in Ann Arbor can be shown as a hospital which implements a waste management method. This facility recycled more than 1350 kg of compression sleeves which led them to save almost $236,000 and 7000 liter of formalin, xylene and alcohol (Hampton 2007). In addition to these, they made money by selling the old linens to the automotive industry and they started to use a paperless employment system which allows them to reduce the paper waste (Hampton 2007).

Kaiser Permanente, headquartered in Oakland, California is implementing a program provided by "Green Guide for Health Care" where they preferred using sustainable materials for its 2.7 million square foot facilities and this kept them from producing 70 billion pounds of air pollutants every year and from generating 40 tons of harmful chemical materials (Hampton 2007).

Some of the green hospitals are using the construction material obtained from the destruction of old building after recycling it. With this method they save money by not disposing the demolished material to a landfill, they prevent use of too much new raw materials and they construct the new building in a way that it looks similar to the existing building if it is an addition to the existing structure.

Darthmouth-Hitchcock Medical Center, in Lebanon, NH is another healthcare facility which recycles more than 30% of its waste like xylene and alcohol. This feature leads them to save $48,000 each year for the disposal of chemical waste (Hampton 2007).

If hospitals apply an efficient health care waste management system, they could see the benefits that they would gain from this like cost savings, environmental impact or healthier work places and many other hospitals would start to implement a waste management plan. By this way people could have a healthier world and they could reduce their cost of business.

3.5.2 Features to Increase Patient Satisfaction

Some of the LEED features, besides having less harmful impact on environment or decreasing the O&M cost, they also affect the patients' satisfaction that spend hours or days at a health care facility. These features can be applied to the patient rooms, common areas which are designated for the relatives of the patients, or gardens to obtain a better view for the occupants. The reasons behind implementing sustainable practices to increase patients' satisfaction and to provide better patient rooms are to;

- install sustainable materials and technologies which cost less and have a long life cycle compared to the other health care materials,
- increase the quality of patient services, make the families willing to visit their patients and decrease the stress of both patient and staff,
- "create a focal point for discussing the issues and solutions affecting hospitals today" (Fischer 2008)

According to the researches that have been done previously, it is claimed that with the increased number of times of families visiting the patients, the healing process gets faster and patients respond more efficiently to the medical treatments. Therefore it is hospitals' responsibility to provide an environment which encourages families to stay longer at the hospitals or visit their patients more often (Fischer 2008). These can be provided by applying some of the features listed below.

Green Patient Rooms: They are designed to allow families and patients stay in comfortable and non-stressful rooms which look almost like a regular living room of a house. TV, sleeper sofa, workspace with internet access and a wall unit with a bench and storage seals are some of the features which can be found in these rooms (Fischer 2008). Also spacing of the night light is another issue which has to be taken care seriously, because if it's not mounted to the optimum place, there could be a need to assemble extra lights to increase the visibility and brightness of the room during night time. Therefore before mounting it designers usually analyze it by using software to find the perfect spot for the night light. The night lights are very important, since nobody wants the patient to fall during his/her stay because of inefficient night light which could result in serious damages. Usually designers prefer to use LED for the night light, as they consume 6 watts of energy and they keep functioning for couple of years (Fischer 2008).

In addition to these, a family area is located nearby the rooms to keep the families' morale high during the time where patient receives treatment.

Noise Reduction: Uncontrolled noise in the environment usually impacts the patients and the other people in a negative way. In the hospital the sources of these noises can be numerous like sirens, heart monitor alarms, telephones ringing, nebulizer, etc. According to the previous research, there are couples of effects of the noise which impact the patients in a negative way (Pearson and Short 2011).

- It decreases the staff productivity and could lead to medical errors.
- Decreases the pace of the healing process of the patient.

The methods to keep the room of the patient silent are;

- closing the doors when nobody is entering or leaving,
- decreasing the sound of the telephones,
- dimming lights, (which keeps the fluorescents silent, because they might make noise when they are in use)
- buying equipment which make less sound (Devlin and Arneill 2003).

These methods would help to decrease the level of noise in the hospital, increase the patients' satisfaction and reduce the waste of money and material for the sound insulation.

Large Windows: Natural light is another factor which impact the patients' well-being and recovery process and in addition to this it is also important for the energy conservation. Moreover the hospital staff is also affected in a good way with the use of large windows. Installing large windows provide a brighter, less stressful environment

which also allows patients to see the nice view if there is one. In a research done to understand the effect of the views out of windows on the healing process of patients after gallbladder surgery, a researcher compared the rooms which have a nice view to the ones with a 'brick view' which reflects the narrowness of the windows in the room. After completing his study, he claimed that patients who stayed in a room with smaller windows spend more time to recover after the surgery, their nurses were not as helpful as the other ones who were working at a brighter patient room, they took more painkillers and had more complications after the surgery (Devlin and Arneill 2003).

Another researcher tried to figure out the ways to improve the lighting problem and he came up with solutions like decreasing the glare, increasing the daylight in the building, decreasing the facility's lighting and providing lighting which is similar to the one that someone would find at his/her house (Devlin and Arneill 2003).

3.5.3 Features to Increase Staff Satisfaction

Sustainable design has some positive impact also on the staff which indirectly affects the customer satisfaction in a way that, if the hospital staff is doing their jobs in a better and healthier environment, they would be willing to do their best with helping the patients and this would increase the patients satisfaction and eventually lets the hospital get good feedback from the patients who received treatment at that hospital. The features that have been mentioned in the previous subsection help to increase also the staff satisfaction; however the ones listed below are making additional contribution to that fact.

Outdoor Places: As stated by the Green Guide for Health Care, hospitals should design an outdoor area which occupies at least 5% of the net area of the facility for the outdoor activity usage where staff can go out to get some fresh air, have a walk to get rid of their stress or gather with their colleagues to talk about anything (Bush 2008). Adding green vegetation to the outdoor spaces which won't require too much water could help to increase the positive outcome of these places. Jerry Smith from HDR Engineering says about outdoor areas "for staff it's a place to unwind, for visitors a place to grieve or catch their breath and for the patient it offers healing opportunities" (Bush 2008). Actually on of the 114 LEED certified hospitals, Aurora Saint Luke's Medical Center received its certificate thanks to its healing garden.

Cafeteria and Kitchen: As it is well known, hospitals have to serve food to the patients staying overnight; therefore they need to use many ingredients and energy to prepare the foods. The administrators are trying to minimize the impact on environment by changing some of the features at the cafeteria where they serve food for the staff or visitors and at the kitchen where they cook for the patients. Metropolitan State hospital in Norwalk, CA won LEED certificate for their kitchen. Other than this the Concord Hospital in Concord, NH took out some of the meals from their menu like fried foods, and added some healthier food. They were expecting a reduction at their revenues, because most of the people like to eat fried foods; however their revenues increased after they started to supply healthier foods (Sattler 2007).

Reducing the use of Chemicals: Hospitals need to consume too much chemical products to keep their environment out of viruses or infections, because hundreds of sick

people are visiting these facilities every day. Doctors and nurses are spending hours in the same rooms with patients; therefore these rooms have to be sterilized so the staff won't get sick. However, while trying to clean the facility the chemical materials used could be the sources of new diseases for the hospital staff. They could contain some ingredients which might be really dangerous for both the staff and the environment.

A study completed in U.S. hospitals reflects that nurses are the ones who get caught to work-related asthma more than in any other profession. Cecila DeLoach, Senior Manager of sustainable operations for Practice Greenhealth, explains this issue with the exposure of nurses to the cleaning chemicals. Hospitals which recognize this problem, they started to prefer cleaning products that are not as detrimental as regular chemical cleaners (Bush 2008).

According to the results of a survey conducted between the nurses, it is claimed that the nurses want the flooring materials of newly constructed areas to be a product which don't need waxing, so the chances of being exposed to waxes and wax strippers could be reduced (Sattler 2007).

Another contribution to the environment made by the hospitals is to use organic cotton linens, because there is no need to use pesticides while growing the cotton. As it is known quite well, the pesticides are very harmful for the environment; therefore with the use of cotton, hospitals prevent the extra usage of pesticides which helps to keep the environment clean and the staff healthy.

3.5.4 Indoor Environmental Quality

Indoor Air Quality(IAQ): As mentioned in the previous subsection infection is one of the biggest problems that the hospitals should deal with. Ventilation and airflow management can provide better indoor air circulation at the hospitals, so the infectious particles in the air can be sent out of the facility without causing any illnesses. Engineers are working on new technologies to optimize the indoor air quality by controlling the moisture in the air to prevent molding, by using pressure changes to let the air particulates move or by installing air disinfection systems (Riley et al. 2004).

The problems related to IAQ are usually because of;

1) Not enough ventilation
2) Plenty of infectious particulates in the air (Kaushal and Gupta 2004).

These problems can result in serious damages on people and they even can cause death of many healthy people by making them infected. According to The Center for Disease Control and Prevention the number of people got infected in hospitals in the U.S. is more than 2 million and 88,000 of these people were dead because of this issue. Well-designed airflow systems can both prevent these from happening and they can also let the hospitals save money on the energy costs (Riley et al. 2004).

There are 3 reasons why the indoor air flow management in hospitals is very important.

1) There are so many patients with viruses in the hospitals
2) Facilities are usually very crowded and the patients are mostly in contact with other patients

3) Hospital facilities are designed to last for many years, usually at least 50 years, so their ventilation systems get old during this period and they need to be maintained frequently.

Hospitals are in need of some techniques to make their airflow systems function well. One of them is the HVAC Systems. One application used the most in hospitals is the negative pressure in the infectious isolation rooms to prevent the contaminated air transfer to other rooms. An example of well-designed HVAC System is located at the Children's Hospital in Fort Worth, Texas which is installed when the hospital was being renovated. In the waiting rooms the HVAC was designed to transfer the air from inlet to outlet without mixing it with the non-contaminated air. With this method nobody would have to inhale the contaminated air. They also installed a HEPA filter, where they direct the air so it can pass through this filter and the filter holds 99.99% of the infectious air particles. This eliminates the need for an outside air system to get the air non-contaminated by letting the hospital save money on the energy costs (Riley et al. 2004).

Material Selection: Also the building materials might affect the indoor environmental quality and patients, because the maintenance and the cleaning of building materials could require chemical products which might lead to harmful impacts on the air quality and on the patients. With better air quality more patients would prefer those hospitals for their treatment and the staff productivity would increase which would grow the hospitals reputation (EPA 2007). The type of materials that have to be selected carefully while designing the hospitals are "adhesives used for finishing; carpets for flooring; caulk applied to tile, wall, flooring seams; finish applied to woodwork, casing; interior paints for walls, fixtures, etc.; and sealants" (EPA 2007). Even though selecting

sustainable materials for these product might be more expensive compared to the regular materials, their operating and maintenance costs are cheaper, which helps the hospital save money on the long term and keep the environment clean by decreasing the need for chemical cleaners.

Temperature Control: The temperature in the hospitals should be under control all the time and the problem is that the temperature might need to be different for each room. Especially for the surgery rooms, it is very critical, too; because the surgeons wear multiple layers of cloths and they also need to put on a face mask, hair cover and gloves. Therefore they want to work in cooler rooms; however the patients usually want to stay in warmer rooms for not getting cold. Because of these reasons, hospitals need to install highly efficient temperature control system which saves energy and works perfectly at the same time (Munters Corporation 2009).

Engineers are trying to find the optimum size of HVAC to keep the rooms at the optimum temperatures. According to a study, optimum temperatures and relative humidity (RH) for different types of rooms in a hospital are listed below and also reflected in Figure 3.3 (Munters Corporation 2009).

- Operation Rooms: 60^0F and 50% RH
- Common Areas: 75^0F and 50% RH

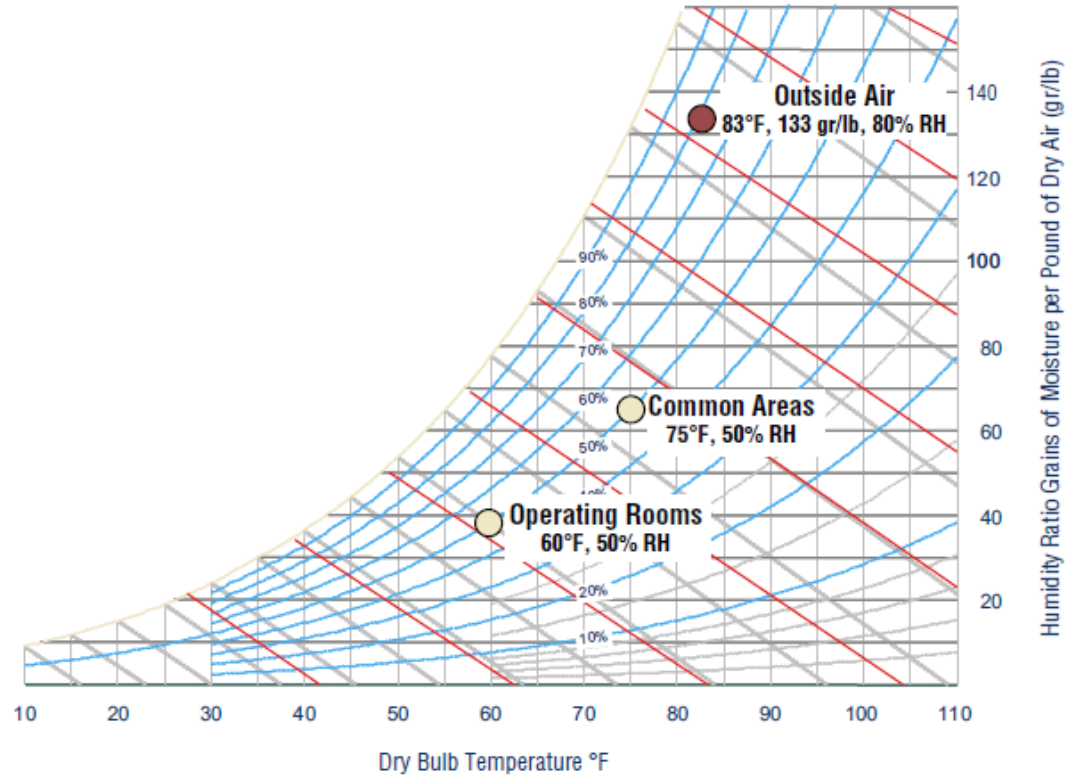

Figure 3.3 Optimum Temperature and Relative Humidity for Hospitals (Munters Corporation 2009)

As the humidity increases, the chance of mold and fungi increases and also the metal equipment start to oxidize. Therefore it is essential to keep it at a decent level.

In conclusion, we all know that hospitals are places full of patients and they need a healthier indoor environment which should be obtained without damaging the environment and which should let the hospital spend less on the energy costs.

3.5.5 Water Management

Based on the censuses made in the 20th century, the world's population got three times bigger and it is anticipated that the number of people on earth is going to increase 40-

50% more in the next fifty years. However the amount of water is not increasing as much as the number of people living in the world which will make the people suffer from lack of water and this will reveal crucial impacts on the environment (World Water Council 2011). In these days, one out of six people cannot find safe drinking water; therefore some sustainability experts name the water as the "new oil" in the Western and Southern parts of U.S. where there is already scarce water (Ferenc 2010). Figure 3.4 depicts the areas where people suffer from lack of water. This figure is also called The Water Stress Map.

Health care facilities are one of the biggest water consumers all over the world, in other words based on the previous measurements it is found that the daily water usage at the hospitals is ranging from 40 gallons per day to 350 gallons per day. This wide range is caused by the location, size, age, etc. of the facility. One example of a case study where the researchers measured the water consumption and categorized it in different groups is medical facilities of Massachusetts (Taddonio 2011). According to the measurements, they prepared the distribution represented in figure 3.5.

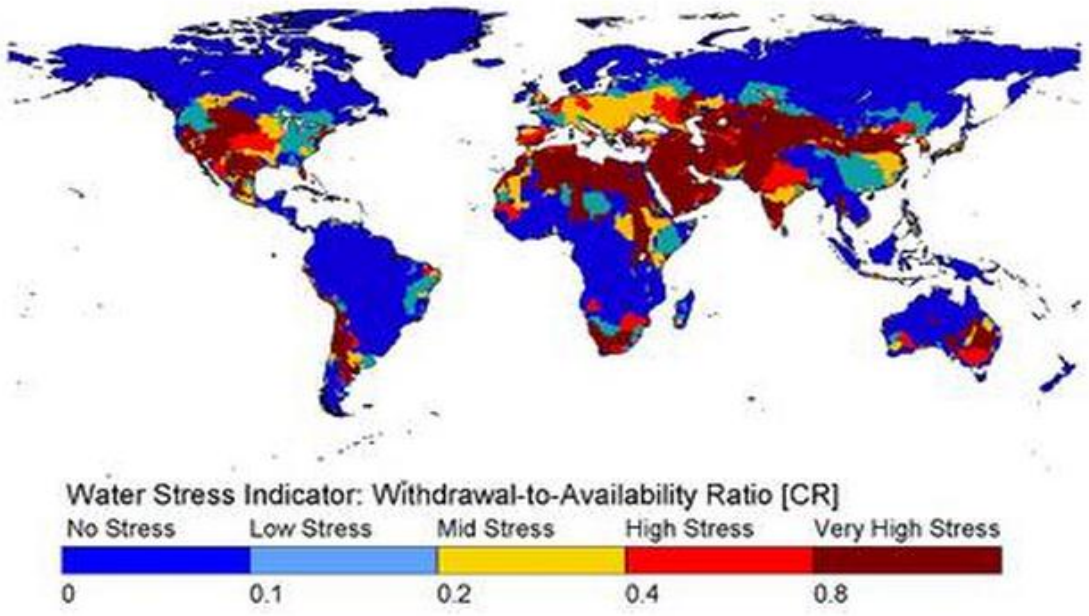

Figure 3.4 Water Stress Indicator (World Water Council 2011)

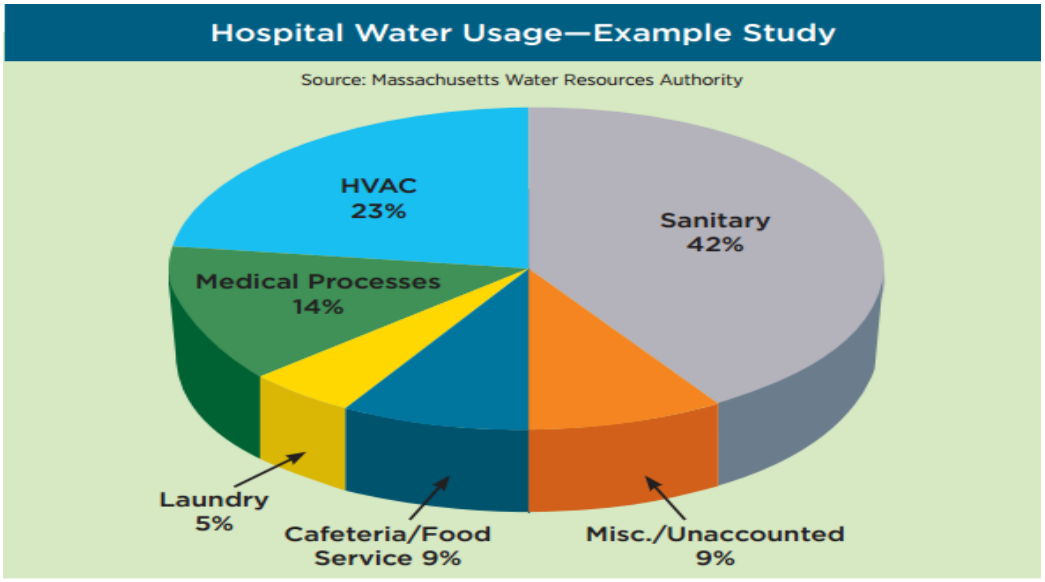

Figure 3.5 Hospital Water Usage (Taddonio 2011)

To reduce the water consumption, there are several methods that the hospitals can follow. First thing to do is to use better technologies for the toilets, showers and faucets. Other than these, the HVAC system is a big source of water waste. To decrease the water consumption at the HVAC's;

- less amount of hot water usage can reduce both the water and energy waste
- Cooling the facility with the help of a cooling tower, reduces the need of heat rejection which decreases the amount of waste water
- Having optimized control systems for cold water plant may decrease the need for energy and water (Taddonio 2011).

In a survey conducted by American Society for Healthcare Engineering (ASHE) which is called Energy Efficiency Indicator (EEI) survey, hospitals told the practices that they are using for going greener. According to the results of the survey, top water conservation methods are listed below (Ferenc 2010).

- "Install flow control fixtures on the faucets"
- "Install low-flow fixtures for toilets and urinals"
- Take care of the leaks, drips and needless flows
- Plant vegetation which is drought tolerant and don't require frequent watering
- Purchase dishwasher which uses less amount of water
- Apply a water management system or plan
- Use dry-cleaning methods like microfiber mops or cleaning clothes for the floors and surfaces.

3.5.6 Energy Efficiency

As mentioned, hospitals are operating 24 hours a day and 7 days a week that reveals the need of large amounts of energy to keep the equipment and hospital running. Therefore health care facilities are one of the largest energy consumers of all building types, and the money that they are spending on the energy costs represents a significant percent of their total expenses. Gail Vittori, co-director of the Austin, Texas design outfit the Center for Maximum Potential Building Systems, claims that the energy costs are almost 2% of the total operating expenses (Bush 2008). With using sustainable design methods they can reduce this amount to a decent level and save some money and protect the environment.

The Green Guide for Health Care suggests some practices to be used at the hospitals to decrease the energy consumption which are listed below (Bush 2008).

- Installing light which consumes less energy than the regular light
- Maximizing the benefit got form daylight
- Designing the HVAC system separately for the rooms where the temperature changes frequently and for the regular rooms where the temperature is mostly stable.
- Increasing the quality of insulation of the rooms to prevent the rooms' temperature fluctuating, so the air conditioner would not need to operate constantly to adjust the temperature.

Other than these, there are also different kinds of methods used by health care facilities. For example, at The Southeast Regional Treatment Center, Madison, Indiana energy managers examined the walls to find an optimum thickness for keeping the room insulated. Based on the outcomes they obtained, they constructed the walls with

reasonable thicknesses and provided an energy efficient facility (Buckley and Smyth 2007).

According to Energy Efficiency Indicator (EEI) survey half of the managers of the hospitals which completed the survey complained about the shortage of capital that they could spend on the energy conservation method. Even though they realize how much money they spent on the energy, they don't have enough money for investing in the new technologies. Therefore in the results of the survey it is stated that 49% of the hospitals are planning to invest only 4% or less of their capital budget on the energy efficient practices (Ferenc 2010). The results of the survey also give idea about the method that the hospitals are using to save money on the energy costs (Ferenc 2010).

- 73% uses energy-efficient lamps, ballasts or lighting fixtures
- 57% optimized the HVAC to prevent unnecessary energy waste
- 56% started to use daylight sensors
- 56% enhanced the building automation system
- 41% purchased new equipment to replace the ones which came to end of its useful life
- 23% replaced the existing windows with the energy saving ones

Besides these entire methods, most of the hospitals started to use wind power, hydropower or geothermal power to run the facility without polluting the environment or by minimizing their harmful impact on the environment.

Some of the LEED certified hospitals are converting their roofs to "green roofs" increase the quality of the insulation of the roof. Green roofs are spaces where at the

bottom there is a layer of waterproofing membrane and on top the membrane layer there are different kinds of vegetation which cover most of the surface area of the roof. They help to save energy by preventing the energy transfer from the roof- one of the most significant spot where the buildings lose heat- to outside. Other advantages of the green roofs are decreased level of noise, improved impermeability for the roofs, positive impact on the environment, etc. (Green Roofs for Healthy Cities 2012). In line with these claims, National Research Council of Canada declares that with the use of green roofs, the hospitals diminished the energy consumption by 75% during summer by reducing the need for air conditioning (Green Roofs for Healthy Cities 2012).

Additional practices used by other LEED certified hospital are;

- turning the lights off when there is no need to use them,
- purchasing Energy Star rated equipment for the kitchen,
- installing a fixture which turns the A/C off when the windows are opened.

4. DATA ANALYSIS

In this section, the details regarding the data used to obtain the results, the methods applied to get the conclusions and the outcomes of the analysis are explained in detail. First the discussion is regarding the evaluation and comparison of the results of the HCAHPS depending on two different types of hospitals (LEED certified vs. non-LEED certified), and then it ends with a decision to accept or reject the claims mentioned in the literature review and hypothesis I. According to the claims, LEED certified hospitals should perform better with regards to patient and staff satisfaction. After analyzing the data of patient satisfaction, the next study is going to be focus on the financial indicators such as operation of plant, total operating expenses and total patient revenues for comparing the financial outcomes of LEED certified hospitals to the non-LEED certified ones.

4.1 Patient/Staff Satisfaction

The literature review documents that sustainable hospitals have a significant positive impact on the patients' and staffs' satisfaction. Therefore a survey that is applied in the hospitals located all over U.S. is required. The survey is called the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) and more information about the survey is provided in the next subsection.

4.1.1 HCAHPS Data

This survey is formed of 6 sections which contains 27 questions in total. The 6 sections are titled as “your care from nurses”, “your care from doctors”, “your experience in this hospital”, “when you left the hospital”, “overall rating of hospital” and “about you”. First 5 sections include 22 questions and these questions are used to determine the overall rating of the hospital and the decision of the patients about recommending the hospital to their family and friends. “About you” section is just to obtain some data related to the patients and they are mostly personal questions like education, ethnicity or native language, etc. The whole survey can be found in the Appendix A. This survey is completed by the patients who spent at least a night at the health care facility. As mentioned on page 6, the author will use 9 questions from this survey to examine the results. These questions are reflecting the performance level of the nurses and the doctors, the quality of the indoor environment. It is claimed by the researches that the hospital buildings help to improve the satisfaction of both the patients and the staff by letting the staff perform better and be more productive. If this is correct the staff working in the LEED certified buildings should be more helpful to the patients and increase the satisfaction level of the patients about the hospital. Other than this, it is also claimed that the facility itself makes the patients satisfied about the hospital by providing a high quality indoor environment quality which is cleaner, quieter and brighter.

7 out of these 9 questions have 4 options to choose as an answer which are “always”, “usually”, “sometimes” and “never”. In the database where the results of the survey are reflected, they grouped “sometimes” and “never” in one group and obtained 3 answers

for each question. Then they showed the percentages of people who selected one of those 3 options. To give an example to show how the data looks like, a sample dataset is ported in table 4.1.

It reflects only 23 of 3,533 non-LEED certified hospitals and it is just for one question. The original excel spreadsheet contains results for 10 questions and 4,488 hospitals. However the data needed to be cropped to have a fair comparison between all the hospitals. First of all, one of the questions is taken out, because it is assumed that it didn't have a strong relationship with green hospital design. Another thing which needed cropping was the number of hospitals, because for some of the hospitals' results were just "N/A" for all the questions. The reason of this was there was no data reported during the period when the datasheet was being prepared. After deleting the hospitals which were containing "N/A" still there were some lines which had a note at the end saying that "Fewer than 100 patients completed the HCAHPS survey. Use these scores with caution, as the number of surveys may be too low to reliably assess hospital performance" Therefore this data was taken out, too. At the end the total number of surveys which have more than 100 patient attendance and have results for each question were 3,533.

Table 4.1 Sample Table from HCAHPS Database

Provider Number	Hospital Name	City	State	ZIP Code	Percent of patients who reported that their nurses "Sometimes" or "Never" communicated well.	Percent of patients who reported that their nurses "Usually" communicated well.	Percent of patients who reported that their nurses "Always" communicated well.
010001	SOUTHEAST ALABAMA MEDICAL CENT.	DOTHAN	AL	36302	9%	19%	72%
010005	MARSHALL MEDICAL CENTER SOUTH	BOAZ	AL	35957	4%	16%	80%
010006	ELIZA COFFEE MEMORIAL HOSPITAL	FLORENCE	AL	35631	5%	17%	78%
010007	MIZELL MEMORIAL HOSPITAL	OPP	AL	36467	4%	19%	77%
010008	CRENSHAW COMMUNITY HOSPITAL	LUVERNE	AL	36049	6%	21%	73%
010009	HARTSELLE MEDICAL CENTER	HARTSELLE	AL	35640	4%	12%	84%
010010	MARSHALL MEDICAL CENTER NORTH	GUNTERSVILLE	AL	35976	3%	14%	83%
010011	ST VINCENT'S EAST	BIRMINGHAM	AL	35235	4%	15%	81%
010012	DEKALB REGIONAL MEDICAL CENTER	FORT PAYNE	AL	35968	6%	17%	77%
010015	SOUTHWEST ALABAMA MEDICAL CENT.	THOMASVILLE	AL	36784	6%	15%	79%
010016	SHELBY BAPTIST MEDICAL CENTER	ALABASTER	AL	35007	5%	18%	77%
010019	HELEN KELLER MEMORIAL HOSPITAL	SHEFFIELD	AL	35660	4%	16%	80%
010021	DALE MEDICAL CENTER	OZARK	AL	36360	10%	19%	71%
010022	CHEROKEE MEDICAL CENTER	CENTRE	AL	35960	3%	17%	80%
010023	BAPTIST MEDICAL CENTER SOUTH	MONTGOMERY	AL	36116	7%	17%	76%
010024	JACKSON HOSPITAL & CLINIC INC	MONTGOMERY	AL	36106	6%	15%	79%
010025	GEORGE H. LANIER MEMORIAL HOSP.	VALLEY	AL	36854	7%	16%	77%
010027	ELBA GENERAL HOSPITAL	ELBA	AL	36323	2%	16%	82%
010029	EAST ALABAMA MEDICAL CENTER	OPELIKA	AL	36801	4%	14%	82%
010032	WEDOWEE HOSPITAL	WEDOWEE	AL	36278	6%	14%	80%
010033	UNIVERSITY OF ALABAMA HOSPITAL	BIRMINGHAM	AL	35233	5%	16%	79%
010034	COMMUNITY HOSPITAL INC	TALLASSEE	AL	36078	4%	15%	81%
010035	CULLMAN REGIONAL MEDICAL CENTER	CULLMAN	AL	35058	6%	18%	76%

To determine which LEED certified hospitals will be considered in this survey, two criteria were selected. One of them is the total square footage of the LEED certified building, and the second one is the number of departments which the LEED-certified facility incorporates. Looking at the LEED-certified health care facilities in some cases just one or couple of departments of the hospital was located in the LEED certified structure; however in some of them the whole building was LEED certified. From American Hospital Directory (AHD) website the author was able to find provider IDs related to only 54 out of 114 LEED certified hospitals. For the first criteria 50,000 square feet and for the second criteria more than two departments were selected. Table 4.2 lists all the LEED certified hospitals which will be compared to the national average.

Table 4.2 LEED-Certified Hospitals Considered in the HCAHPS

Prov. ID	Hospital Name	City	St.	Z. Code
360163	CHRIST HOSPITAL	CINCINNATI	OH	45219
230236	METRO HEALTH HOSPITAL	WYOMING	MI	49519
140119	RUSH UNIVERSITY MEDICAL CENTER	CHICAGO	IL	60612
500027	SWEDISH MEDICAL CENTER	SEATTLE	WA	98122
60027	BOULDER COMMUNITY HOSPITAL	BOULDER	CO	80304
230059	SAINT MARY'S HEALTH CARE	GRAND RAPIDS	MI	49503
330307	CAYUGA MEDICAL CENTER AT ITHACA	ITHACA	NY	14850
300001	CONCORD HOSPITAL	CONCORD	NH	3301
60011	DENVER HEALTH MEDICAL CENTER	DENVER	CO	80204
390189	SHAMOKIN AREA COMMUNITY HOSPITAL	COAL TOWN	PA	17866
420073	LEXINGTON MEDICAL CENTER	WEST COLUMB.	SC	29169
200039	MAINE GENERAL MEDICAL CENTER	AUGUSTA	ME	4330
390116	MERCY SUBURBAN HOSPITAL	NORRISTOWN	PA	19401
380037	PROVIDENCE NEWBERG MEDICAL CENTER	NEWBERG	OR	97132
490004	ROCKINGHAM MEMORIAL HOSPITAL	HARRISONBURG	VA	22801
520009	ST ELIZABETH HSPTL	APPLETON	WI	54915
330101	NEW YORK-PRESBYTERIAN HOSPITAL	NEW YORK	NY	10021

Table 4.2 Continued

Prov. ID	Hospital Name	City	St.	Z. Code
490024	CARILION MEDICAL CENTER	ROANOKE	VA	24033
500051	OVERLAKE HOSPITAL MEDICAL CENTER	BELLEVUE	WA	98004
440184	FRANKLIN WOODS COMMUNITY HOSPITAL	JOHNSON CITY	TN	37601
390006	GEISINGER MEDICAL CENTER	DANVILLE	PA	17822
390270	GEISINGER WYOMING VALLEY MEDICAL CENTER	WILKES BARRE	PA	18711
390133	LEHIGH VALLEY HOSPITAL	ALLENTOWN	PA	18105
60119	MEDICAL CENTER OF THE ROCKIES	LOVELAND	CO	80538
440049	METHODIST HEALTHCARE MEMPHIS HOSPITALS	MEMPHIS	TN	38104
370232	MUSKOGEE COMMUNITY HOSPITAL	MUSKOGEE	OK	74402
150167	ORTHOPAEDIC HOSPITAL AT PARKVIEW NORTH	FORT WAYNE	IN	46845
240053	PARK NICOLLET METHODIST HOSPITAL	SAINT LOUIS	MN	55426
100113	SHANDS HOSPITAL AT THE UNIV. OF FLORIDA	GAINESVILLE	FL	32610
100135	TALLAHASSEE MEMORIAL HEALTHCARE	TALLAHASSEE	FL	32308
260141	UNIVERSITY OF MISSOURI HEALTH CARE	COLUMBIA	MO	65201
410010	WOMEN AND INFANTS HOSPITAL OF RH. ISL.	PROVIDENCE	RI	2905

4.1.2 Methodology for HCAHPS Survey Evaluation

For comparison of the two datasets LEED certified hospitals to non-LEED certified hospitals there was a need to calculate the general score of hospitals for each question. Table 4.3 reflects the questions, possible answers and the method of calculating the general scores.

Table 4.3 Method of Calculation of the General Score

Survey Question	**Possible Answers**	**Method of Calculation of the General Score**
How often did the nurses communicated well with you?	**a**. Always **b**. Usually **c**. Sometimes or Never	# **a** has positive impact on the general score # **b** has no impact on the general score # **c** has negative impact on the general score Therefore the equation is equal to **Percent of a- Percent of c**
How often did the doctors communicated well with you?		
How often did you receive help as soon as you want?		
How often your pain was well controlled?		
How often did the staff explained about the medicine before giving it to you?		
How often your bathroom was clean?		
How often the area around your room was quiet at night?		
What number would you use to rate this hospital?	**a**. 10-9 **b**. 8-7 **c**. 6-low	
Would you recommend this hospital to your friends and family?	**a**. Definitely yes **b**. Probably yes **c**. No	

After applying this formula the general scores of hospitals for each question are calculated. Table 4.4 shows how the spreadsheet looks after applying the method reflected in table 4.3. Then the mean of non-LEED certified hospitals and LEED certified hospitals are found separately question by question and these means were compared by using the t-test (two samples assuming unequal variances) to see if the mean of the sample group is significantly different or not. In the next section the comparison and the results of t-tests are shown for each question.

Table 4.4 Sample Results for One Question

Provider Number	Hospital Name	State	ZIP Code	Percent of patients who reported that their nurses "Sometimes" or "Never" communicated well.	Percent of patients who reported that their nurses "Usually" communicated well.	Percent of patients who reported that their nurses "Always" communicated well.	General Score for Question
10001	SOUTHEAST ALABAMA MEDICAL CENTER	AL	36302	9%	19%	72%	**63%**
10005	MARSHALL MEDICAL CENTER SOUTH	AL	35957	4%	16%	80%	**76%**
10006	ELIZA COFFEE MEMORIAL HOSPITAL	AL	35631	5%	17%	78%	**73%**
10007	MIZELL MEMORIAL HOSPITAL	AL	36467	4%	19%	77%	**73%**
10008	CRENSHAW COMMUNITY HOSPITAL	AL	36049	6%	21%	73%	**67%**
10009	HARTSELLE MEDICAL CENTER	AL	35640	4%	12%	84%	**80%**
10010	MARSHALL MEDICAL CENTER NORTH	AL	35976	3%	14%	83%	**80%**
10011	ST VINCENT'S EAST	AL	35235	4%	15%	81%	**77%**
10012	DEKALB REGIONAL MEDICAL CENTER	AL	35968	6%	17%	77%	**71%**
10015	SOUTHWEST ALABAMA MEDICAL CENTER	AL	36784	6%	15%	79%	**73%**
10016	SHELBY BAPTIST MEDICAL CENTER	AL	35007	5%	18%	77%	**72%**
10019	HELEN KELLER MEMORIAL HOSPITAL	AL	35660	4%	16%	80%	**76%**
10021	DALE MEDICAL CENTER	AL	36360	10%	19%	71%	**61%**
10022	CHEROKEE MEDICAL CENTER	AL	35960	3%	17%	80%	**77%**
10023	BAPTIST MEDICAL CENTER SOUTH	AL	36116	7%	17%	76%	**69%**
10024	JACKSON HOSPITAL & CLINIC INC	AL	36106	6%	15%	79%	**73%**
10025	GEORGE H. LANIER MEMORIAL HOSPITAL	AL	36854	7%	16%	77%	**70%**
10027	ELBA GENERAL HOSPITAL	AL	36323	2%	16%	82%	**80%**
10029	EAST ALABAMA MEDICAL CENTER	AL	36801	4%	14%	82%	**78%**

4.1.3 HCAHPS Data Analysis

This subsection incorporates the comparison of two different types of hospitals based on each question.

Question I

- How often did the nurses communicated well with you?

The mean of the non-LEED hospitals = 70.8%

The mean of the LEED-Certified Hospitals = 72.6%

T-test results:

Table 4.5 T-test Results for the Means of Two Sample Group for Nurse Communication Question

t-Test: Nurse Communication		
	Non-LEED	***LEED-Certified***
Mean	0.708361166	0.72625
Variance	0.006889131	0.002398387
Observations	3533	32
Hypothesized Mean Difference	0	
df	33	
t Stat	-2.039953059	
P(T<=t) one-tail	0.024712648	
t Critical one-tail	1.692360309	
P(T<=t) two-tail	0.049425295	
t Critical two-tail	2.034515297	

Based on the results it may accepted that nurses working at the LEED certified hospitals communicate well with the patients more often than the ones working at the non-LEED certified ones and the difference between the means is significant. This may prove that the claims told by previous researches are correct. Working in a brighter, less

stressful environment, and where nurses feel like the facility that they are working in is making less contribution to environmental pollution can help to increase the productivity of the nurses and allows them be more helpful to the patients by increasing their satisfaction about the workplace.

Question II

- How often did the doctors communicated well with you?

The mean of the non-LEED hospitals = 75.6%

The mean of the LEED-Certified Hospitals = 75%

T-test results:

Table 4.6 T-test Results for the Means of Two Sample Group for Doctor Communication Question

t-Test: Doctor Communication		
	Non-LEED	***LEED-Certified***
Mean	0.756071327	0.7496875
Variance	0.005312138	0.001570867
Observations	3533	32
Hypothesized Mean Difference	0	
df	33	
t Stat	0.897501538	
P(T<=t) one-tail	0.187976435	
t Critical one-tail	1.692360309	
P(T<=t) two-tail	0.375952869	
t Critical two-tail	2.034515297	

The results are reflecting that the doctors working at the non-LEED hospitals may be communicating well with the patients more often than the ones who are working at the LEED certified hospitals. However, the difference between the means is not significant.

This outcome conflicts with previous research claims that says doctors would perform better and be more satisfied by working in a green hospital.

One question which comes to mind is that how come the working environment is making significant contribution on the nurses' performance but not on the doctors'. A reasonable answer to this question might be that the nurses do not have personal rooms where they spent most of the day. They are always walking in the facility or visiting the patients' rooms, which allow them to be more affected by the indoor environment; however the doctors are usually staying in their private rooms and focusing on the problems of the patients. Therefore they may not find the chance to notice the environmental features of the hospitals.

Another reason of this outcome could be the personal trait of the doctors. Some people are more helpful than the other ones and no matter how the facility where they are working in is designed, it does not change the way the doctor is behaving. Therefore this issue is open to discussion.

Because of the above reasons, it is acceptable that the facilities may not have much of a positive impact on doctors' satisfaction.

Question III

- How often did you receive help as soon as you want?

The mean of the non-LEED hospitals = 53%

The mean of the LEED-Certified Hospitals = 51.9%

T-test results:

Table 4.7 T-test Results for the Means of Two Sample Group for Receiving Help Question

t-Test: Receive Help		
	Non-LEED	***LEED-Certified***
Mean	0.530427399	0.519375
Variance	0.018300865	0.008877016
Observations	3533	32
Hypothesized Mean Difference	0	
df	32	
t Stat	0.657477149	
P(T<=t) one-tail	0.257787958	
t Critical one-tail	1.693888748	
P(T<=t) two-tail	0.515575917	
t Critical two-tail	2.036933343	

The higher mean at the non-LEED certified hospitals tells that patients treated in those facilities may be receiving quicker help than the ones in the LEED certified hospitals, however the outcome of the t-test reflects that there is no significant proof that the non-LEED are significantly better than the LEED-certified ones. Even though this question is related to staff productivity, it could also be strongly related to how crowded the facility is. If there are so many patients requesting help at the same or close to the same time, the staff would have hard time helping everyone who is in need of help. Therefore, hospitals should know and anticipate the times when they are busiest, and increase their number of health staff to ensure that there is enough employees to help patients. To find a more accurate answer to this question more data is needed related to the total number of patients per day categorized based on their time of visit.

Question IV

- How often your pain was well controlled?

The mean of the non-LEED hospitals = 62.1%

The mean of the LEED-Certified Hospitals = 63.4%

T-test Results:

Table 4.8 T-test Results for the Means of Two Sample Group for Pain Control Question

t-Test: Pain Control		
	Non LEED	***LEED-Certified***
Mean	0.62056043	0.634375
Variance	0.005925167	0.002386694
Observations	3533	32
Hypothesized Mean Difference	0	
df	32	
t Stat	-1.58192307	
P(T<=t) one-tail	0.06175101	
t Critical one-tail	1.693888748	
P(T<=t) two-tail	0.123502019	
t Critical two-tail	2.036933343	

Even though the results of t-test shows that the differences between the means is not significantly different, it is very close to that level and the outcome reflects that the pain control in LEED-certified hospitals may be better than the non-LEED ones as mentioned in the literature review. Researchers have claimed that besides the treatment that patients receive, the building also plays an important role with the patients' recovery period, reduction of pain, and their well-being. It is mentioned that if the health care facility is designed in a way to increase the patient's morale, the patient would focus less on their

illness and be more busy with alternative options such as watching the nice garden from the big windows in the patient room, or by communicating with the nurses that is more committed or helpful in their job. Thus it is highly plausible to accept such a hypothesis based on the results of the t-test.

Question V

- How often did the staff explained about the medicine before giving it to you?

The mean of the non-LEED hospitals = 39.7%

The mean of the LEED-Certified Hospitals = 41%

T-test Results:

Table 4.9 T-test Results for the Means of Two Sample Group for Explain Medicine Question

t-Test: Explain Medicine		
	Non-LEED	***LEED-Certified***
Mean	0.397446929	0.4096875
Variance	0.012423944	0.004893448
Observations	3533	32
Hypothesized Mean Difference	0	
df	32	
t Stat	-0.978660919	
P(T<=t) one-tail	0.167544413	
t Critical one-tail	1.693888748	
P(T<=t) two-tail	0.335088826	
t Critical two-tail	2.036933343	

The mean of LEED-certified hospitals for this question looks better, however the t-test results is not showing a significant difference for two sample groups. Looking at the means of the two groups, it is easy to notice that they are both low and this can give an

idea that medicines usually are not explained by the hospitals staff, instead pharmacists are the ones who gives information about the medicine. Therefore it is not reasonable to make a comparison of two different types of hospitals based on this question. It just lets the readers know that explaining medicine is not very common among the hospital staff.

Question VI

- How often your bathroom was clean?

The mean of the non-LEED hospitals = 62%

The mean of the LEED-Certified Hospitals = 60.8%

T-test Results:

Table 4.10 T-test Results for the Means of Two Sample Group for Bathroom Cleanness Question

t-Test: Bathroom Cleanness		
	Non-LEED	***LEED-certified***
Mean	0.620467025	0.6075
Variance	0.012403094	0.010922581
Observations	3533	32
Hypothesized Mean Difference	0	
df	32	
t Stat	0.698281806	
P(T<=t) one-tail	0.245022338	
t Critical one-tail	1.693888748	
P(T<=t) two-tail	0.490044675	
t Critical two-tail	2.036933343	

Based on the comparison of the means of two sample groups, non-LEED hospitals are cleaner than the LEED certified ones, yet the difference is not very significant.

However based on the research mentioned in the literature review, it is reasonable to assume that LEED-certified hospitals would be cleaner than non-LEED hospitals.

Giving further consideration, cleaner bathrooms for non-LEED hospitals may indeed make more sense, because LEED certified ones are minimizing chemical and water usage to a very low level, preventing the high amount of water usage during the cleaning process by using mops which don't require water, etc. This type of scenario provides some level of logic to the result. Chemical materials used for cleaning bathrooms are containing additives which make them smell better, fresher; but whenever the staff is not using any harmful chemical to environment, even though the bathroom is clean, the patient thinks that it is not clean enough, because it does not have a nice scent or it does not shine as the bathrooms where chemicals are used.

Also constraints on the amount of water usage might cause the bathrooms to be not very clean. Removing the dirt by just using a special mop would clean the bathrooms, but it would not make them to be cleaner according to the patients compared to the bathrooms of the regular hospitals.

The cleaning procedure of hospitals is very crucial for Evidence Based Design (EBD) which is mentioned in the literature review. LEED criteria and EBD criteria are mostly conflicting with each other. EBD requires the hospital as clean as it can be without having any constraints on the method of cleaning, whereas LEED tries to prevent waste water and usage of chemicals. EBD is applied in most of the hospitals which would allow the non-LEED hospitals have a cleaner environment.

Question VII

- How often the area around your room was quiet at night?

The mean of the non-LEED hospitals = 46.4%

The mean of the LEED-Certified Hospitals = 44.4%

T-test Results:

Table 4.11 T-test Results for the Means of Two Sample Group for Noise Level at Night Question

t-Test: Noise Level at night		
	Non-LEED	***LEED-Certified***
Mean	0.464263	0.44375
Variance	0.023144	0.019082258
Observations	3533	32
Hypothesized Mean Difference	0	
df	32	
t Stat	0.83543	
P(T<=t) one-tail	0.204835	
t Critical one-tail	1.693889	
P(T<=t) two-tail	0.40967	
t Critical two-tail	2.036933	

The means of two sample groups reflect that designing the health care facilities based on the LEED criteria does not make the patients' room quieter; on the contrary the ones in the non-LEED hospitals look quieter according to the survey results. The consequence of the t-test is not significant, yet still it is conflicting with the research mentioned in the literature review.

There might be numerous reasons for this consequence. First of all it depends mostly on how crowd or busy the hospital is, because whenever there is so many people in the

building at the same time, it would be very hard to keep the noise level at a minimum level. Other than this, facts like open doors, sound of sirens, distance of patient rooms to the busy areas, equipment sounds etc. could cause the rooms to be not quiet enough. To have a better comparison, the hospitals should be studied also based on the number of patients during night time; however there is not sufficient data in hand to discuss this issue in this thesis.

In addition to this, another interesting outcome of this question is that both of the hospital types are not very quiet as it can be seen from the means. They are both under 50% which could let the reader understand that hospitals are not very noise reduction system friendly places because of the crowd and loud equipment.

Question VIII and IX

- What number would you use to rate this hospital?

The mean of the non-LEED hospitals = 58.6%

The mean of the LEED-Certified Hospitals = 64.5%

T-test Results:

Table 4.12 T-test Results for the Means of Two Sample Group for Hospital Overall Rating Question

t-Test: Hospital Overall Rating		
	Non-LEED	***LEED-Certified***
Mean	0.586037362	0.6446875
Variance	0.016217589	0.008193448
Observations	3533	32
Hypothesized Mean Difference	0	
Df	32	
t Stat	-3.632889675	
P(T<=t) one-tail	0.000485063	

Table 4.12 Continued

t-Test: Hospital Overall Rating		
	Non-LEED	***LEED-Certified***
t Critical one-tail	1.693888748	
P(T<=t) two-tail	0.000970125	
t Critical two-tail	2.036933343	

- Would you recommend this hospital to your friends and family?

The mean of the non-LEED hospitals = 64%

The mean of the LEED-Certified Hospitals = 72.4%

T-test Results:

Table 4.13 T-test Results for the Means of Two Sample Group for Recommending Hospital Question

t-Test: Recommend Hospital		
	Non-LEED	***LEED-Certified***
Mean	0.640467025	0.724375
Variance	0.015546356	0.007425403
Observations	3533	32
Hypothesized Mean Difference	0	
df	32	
t Stat	-5.456811185	
P(T<=t) one-tail	2.62893E-06	
t Critical one-tail	1.693888748	
P(T<=t) two-tail	5.25785E-06	
t Critical two-tail	2.036933343	

The result of the t-tests for these two questions represents a significant difference between the means of non-LEED and LEED certified hospitals. P-value is less than 0.05

in both cases which proves the claims of LEED-certified hospitals are increasing the patient satisfaction about the hospital.

This outcome shows that, even though some of the previous questions examined in this section are providing better results for non-LEED hospitals, they do not play an important role on the rating and recommendation decision of the patients about the hospital. Overall patients of the LEED-certified hospitals are significantly more satisfied with the hospital staff and building fixtures.

The reasons which might provide these results are listed in the literature review and also in the comments for each question discussed in this section. To sum up the means for each question of the two hospital types are shown in figure 4.1.

4.2 Financial Indicators

In this subsection the non-LEED hospitals and the LEED-certified hospitals are going to be compared based on their financial indicators such as profitability, cost of operation of plant and total inpatient revenues.

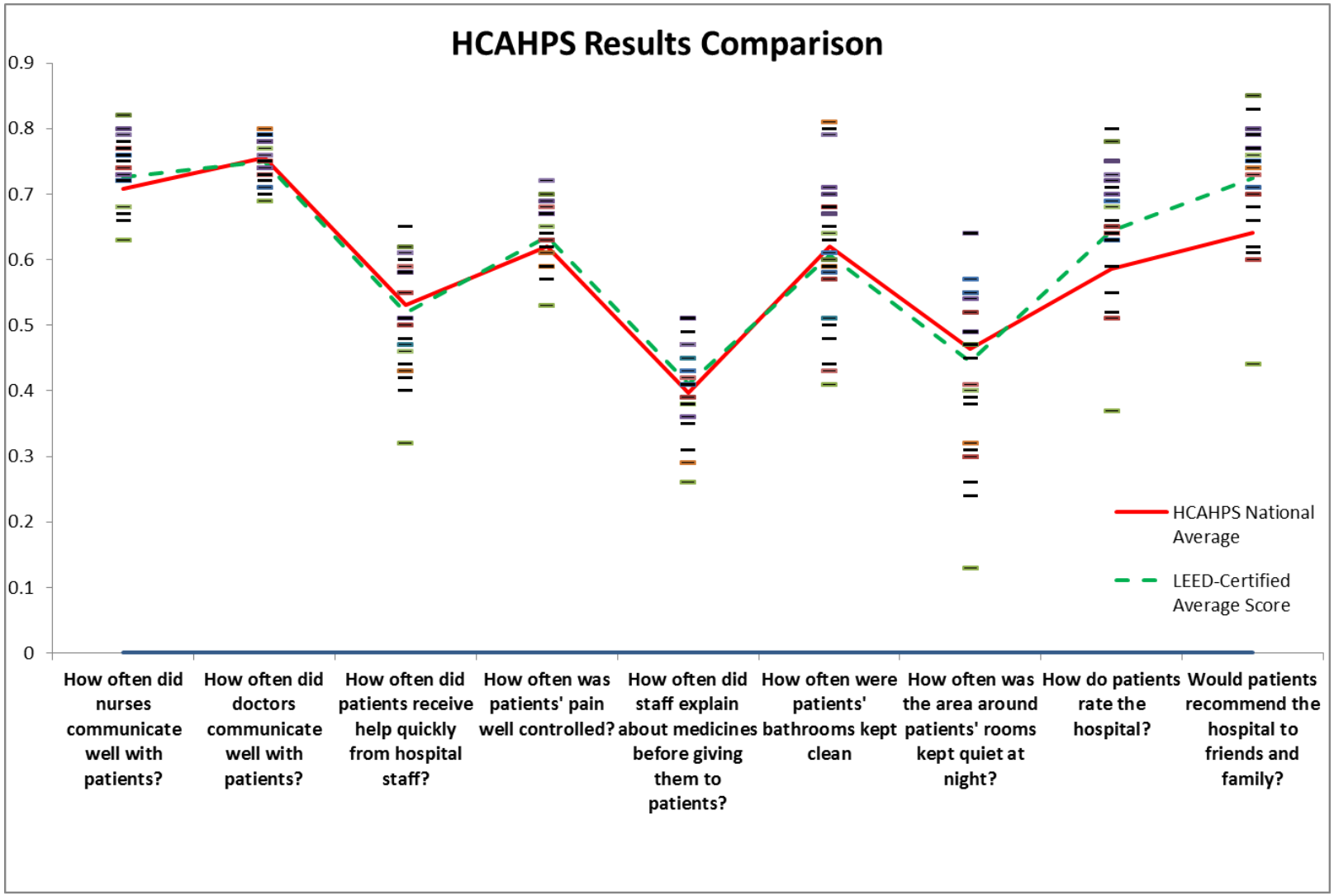

Figure 4.1 Means for Each Question Comparing the National Average to the Means of LEED-Certified Hospitals

4.2.1 Financial Data

As mentioned earlier, there are data related to 53 LEED-certified hospitals and 3469 non-LEED hospitals in the CMS database. These hospitals are categorized based on 6 types of care which are listed in the table below.

Table 4.14 Hospitals Based on Care Type

Type of Care	Number of Hospitals (Non-LEED)	Number of Hospitals (LEED-certified)
Short term acute care	2077	46
Long term acute care	215	0
Critical access	742	1
Psychiatric	203	3
Rehabilitation	141	0
Children	32	4
Other	59	0

Table 4.15 shows the hospitals which own a LEED-certificate for the whole building which are mostly used to have a fair comparison, because the most appropriate way to compare is whole building vs. whole building with the amount of information in hand.

Table 4.15 Hospitals with LEED Certificate for the Whole Structure

Provider ID AHD	Project Name	Location (State)	Type of Facility	Square Feet of LEED certified Structure	No. of Beds
360163	The Christ Hospital	OH	Short Term Acute	901000	451
243302	Children's Specialty Center	MN	Children	160500	202
230236	Metro Health Hospital	MI	Short Term Acute	69224	208
060027	Boulder Community Foothills Hospital	CO	Short Term Acute	153773	171
053303	Children's Hospital and Health	CA	Children	272274	272
453310	Dell Children's Medical Center of Centre	TX	Children	473000	167
050668	Laguna Honda Hospital Repl. Prgm.	CA	Short Term Acute	508414	805
380037	Providence Newberg Medical Center	OR	Short Term Acute	176000	40
490004	Rockingham Memorial Hospital	VA	Short Term Acute	680000	238
524014	Brown County Community Treatm. Center	WI	Psychiatric	100491	100
440184	Franklin Woods Community Hospital	TN	Short Term Acute	238764	91
390006	Geisinger Patient Pavilion	PA	Short Term Acute	261554	427
390133	Lehigh Valley Hospital Cedar Crest North	PA	Short Term Acute	327605	845
060119	Medical Center of the Rockies	CO	Short Term Acute	570400	136
370232	Muskogee Community Hospital	OK	Short Term Acute	95636	15

On the next table the rest of the LEED-certified hospitals are listed.

Table 4.16 Hospitals Which Some Part of the Building is LEED-Certified

Provider ID AHD	Project Name	Location (State)	Type of Facility	Square Feet of LEED certified Structure	No. of Beds
100289	Cleveland Clinic Florida Fourth Floor	FL	Short Term Acute	20600	155
100299	Lakewood Ranch Plastic Surgery	FL	Short Term Acute	3300	120
453304	TCPA Westchase	TX	Children	6885	460
220163	UMass Mem. Medical Center-Ophthalmology	MA	Short Term Acute	15248	684
140119	RUMC Orthopedic Ambulatory Building	IL	Short Term Acute	214553	692
500027	Swedish Medical Center	WA	Short Term Acute	270384	620
154019	Madison State Hospital Building 2	IN	Psychiatric	47300	150
230059	Richard J. Lacks, Sr. Cancer Center	MI	Short Term Acute	170000	344
380047	Bend Memorial Clinic - Westside Clinic	OR	Short Term Acute	14308	260
330307	Cayuga Medical Center Southwest Addition	NY	Short Term Acute	110830	182
300001	Concord Hospital	NH	Short Term Acute	165000	205
060011	Denver Health - Pavilion C	CO	Short Term Acute	212215	352
390189	Geisinger Gray's Woods Ambulatory	PA	Short Term Acute	61000	68
420073	LEXINGTON MEDICAL CENTER MOB-Lexington medical Park 2	SC	Short Term Acute	130000	365
200039	Maine General Cancer Center	ME	Short Term Acute	60000	236
390116	Mercy Suburban Hospital	PA	Short Term Acute	65000	121
054133	Metropolitan State Hospital	CA	Psychiatric	27232	952
520009	St. Elizabeth Hospital - South Addition	WI	Short Term Acute	74978	205
330101	Vivian & Seymour Milstein Family Heart Center	NY	Short Term Acute	106895	2286
230151	Botsford Comprehensive Cancer Center	MI	Short Term Acute	34000	325
230017	Bronson Advanced Radiology	MI	Short Term Acute	26795	384
150128	Community Hospital South - EME	IN	Short Term Acute	31550	143

Table 4.16 Continued

Provider ID AHD	Project Name	Location (State)	Type of Facility	Square Feet of LEED certified Structure	No. of Beds
490024	Carilion Clinic	VA	Short Term Acute	211080	775
500051	Overlake Hospital Medical Center	WA	Short Term Acute	80000	307
470003	Fletcher Allen Radiation Oncology	VT	Short Term Acute	21983	433
390270	Geisinger Wyoming Valley	PA	Short Term Acute	178449	242
360074	Hospice Residence at Flower Hospital	OH	Short Term Acute	13000	468
440049	Methodist LeBonheur Germantown Expansion	TN	Short Term Acute	207972	1296
200041	Inland Hospital	ME	Short Term Acute	3799	46
150167	Ortho Northeast/Parkview Ortho Hospital	IN	Short Term Acute	66513	36
240053	Park Nicollet Cancer Center	MN	Short Term Acute	104739	368
100113	Shands Healthcare-New Cancer Hospital	FL	Short Term Acute	476400	870
100135	TMH Cancer Center	FL	Short Term Acute	51879	603
170049	The Pavilion at Olathe Medical Center	KS	Short Term Acute	43112	222
260141	UMHC Orthopaedic Institute	MO	Short Term Acute	116168	383
410010	Women and Infants Hospital Rhode Island	RI	Short Term Acute	140418	247
151313	Woodlawn Hospital Addition	IN	Critical Access	38521	25

The cost of operation of plant, total operating expenses and patient revenues will be compared based on four different criteria.

1) Comparison of 15 (for profit comparison) and 13 (for cost of operation of plant comparison) LEED-certified hospitals where the whole facility is LEED-certified to the all of the hospitals in the U.S.

2) LEED-certified hospitals that have at least 50000sqf area designed based on the LEED criteria's compared to the non-LEED health care facilities with 50000sqf or more service area.

3) Each LEED-certified hospital that has a LEED certificate for whole structure compared to all of the hospitals which is located at the same state and which has the same type of care (short term acute care, children's, psychiatric, long term, critical access or rehabilitation)

4) Comparison of LEED certified hospitals within the same group based on their LEED certification level(gold, silver or certified)

To have a fair comparison between the hospitals, all of the financial items thatwill be compared need to be normalized by a value which reflects the hospitals' characteristic. One of the criteria used for normalizing is total square foot of the facility which helps to normalize the values used for calculating the profitability (Eq. 4.1) and cost of operation of plant (Eq. 4.2) and the other one is total number of beds that allows the author to normalize the total inpatient revenues.

Equation 4.1

$$Profitability = \frac{Total\ Patient\ Revenue}{Total\ Operating\ Expenses}$$

where the total patient revenue is the sum of total inpatient revenues and total outpatient revenues. The line items included in the total operating expenses is shown in Appendix B. This formula provides the amount of dollars gained when the hospital spends one dollar.

Next equation represents the formula for cost of operation of plant which is the fraction of 'total patient revenues' to the 'operation of plant'.

Equation 4.2

$$\text{Cost of Operation of Plant} = \frac{\text{Total Patient Revenue}}{\text{Operation of Plant}}$$

The value for the operation of plant comes from the worksheet which is added in the Appendix C. This formula calculates the revenue that the hospital is making from its patients per a dollar spent for the operation of plant that excludes all the revenues obtained by the health care services offered.

The third value that will be compared is the 'total inpatient revenue' and this item comes from the worksheet added in Appendix C. All the values used in these formulas are first normalized based on the square foot or the total number of bed of the facility and then the values obtained after normalizing are summed up and divided to the total number of facilities. By this method the average values of total patient revenues, total inpatient revenues, total operating expenses and operation of plant expenses for each hospital group can be found. The discussion starts first with the comparison of the cost of operation of plant of the health care facilities.

4.2.2 Comparison of Cost of Operation of Plant

Operation of plant line item includes costs related to the electric bills, money spent to dispose the harmful wastes, etc. It excludes the money spent for the health care services. Therefore it is related to the total square of the hospital and it also depends on how crowded the hospital is. To normalize this line item, first of all it is divided to the total square footage of the building, and then the value obtained after the division is used to divide the total patient revenue that reflects the level of crowd of the hospital. According to the research reflected in the literature review, there should be a significant difference for this line item between the LEED-certified hospitals and the non-LEED ones. The four criteria listed on page 61 will be followed for the comparison.

1st type of comparison

Table 4.17 Total Patient Revenue/Opt. of Plant Cost of LEED-certified Hospitals

Provider ID (AHD)	LEED Hospital	Total Patient Rev/Opt of plant
060027	Boulder Community Foothills Hospital	83.14
243302	Children's Specialty Center	150.99
380037	Providence Newberg Medical Center	167.27
490004	Rockingham Memorial Hospital	56.18
524014	Brown County Community Treatment Center	12.19
060119	Medical Center of the Rockies	172.28
370232	Muskogee Community Hospital	165.19
360163	The Christ Hospital	107.76
230236	Metro Health Hospital	34.94
053303	Children’s Hospital and Health	161.87
453310	Dell Children's Medical Center of Center	216.60
440184	Franklin Woods Community Hospital	157.88
390006	Geisinger Patient Pavilion	248.16
	Average	**133.42**

The table reflects the average total patient revenues/operation of plant costs of the hospitals where the whole building is LEED-certified as $133.42, whereas the average for all the hospitals in the U.S. is calculated as $196.47. However there were many outliers in the database for the 'operation of plant' line item which was creating confusion, because at first the average is calculated as more than $1000. After looking at the data in more detail, some of the operation of plant costs were unrealistically low. For example, a large number of hospitals had values between $1000-$2000 for the non-normalized values even though they have 60000 or 70000 square foot of service area. This was providing impractical results. Therefore the outliers were cropped and as the average cost $196.47 was obtained. This shows that non-LEED hospitals are spending less money on the operation of plant costs than the LEED-certified ones, but again some values in the database were highly unrealistic.

2nd type of comparison

This is the comparison of the facilities shown in table 4.18 which have more than 50000sqf of LEED certified area to the all of the hospitals in the U.S. In this thesis it is assumed that LEED structures which occupies more than 50000sqf have a significant impact on the overall financial performance of the hospitals.

Table 4.18 LEED-Certified Hospitals in CMS Database with More than 50000sqf of LEED-Certified Area

Provider ID AHD	Project Name	Location (State)	Type of Facility	Square Feet of LEED certified Structure
360163	The Christ Hospital	OH	Short Term Acute	901000
243302	Children's Specialty Center	MN	Children	160500
230236	Metro Health Hospital	MI	Short Term Acute	69224
500027	Swedish Medical Center	WA	Short Term Acute	270384
060027	Boulder Community Foothills Hospital	CO	Short Term Acute	153773
053303	Children's Hospital and Health	CA	Children	272274
330307	Cayuga Medical Center Southwest Addition	NY	Short Term Acute	110830
300001	Concord Hospital	NH	Short Term Acute	165000
453310	Dell Children's Medical Center of Centre	TX	Children	473000
060011	Denver Health - Pavilion C	CO	Short Term Acute	212215
390189	Geisinger Gray's Woods Ambulatory	PA	Short Term Acute	61000
420073	LEXINGTON MEDICAL CENTER-Lexington MP 2	SC	Short Term Acute	130000
200039	Maine General Cancer Center	ME	Short Term Acute	60000
390116	Mercy Suburban Hospital	PA	Short Term Acute	65000
380037	Providence Newberg Medical Center	OR	Short Term Acute	176000
490004	Rockingham Memorial Hospital	VA	Short Term Acute	680000
524014	Brown County Community Treatment Center	WI	Psychiatric	100491
490024	Carilion Clinic	VA	Short Term Acute	211080
500051	Overlake Hospital Medical Center	WA	Short Term Acute	80000
440184	Franklin Woods Community Hospital	TN	Short Term Acute	238764
390006	Geisinger Patient Pavilion	PA	Short Term Acute	261554
390270	Geisinger Wyoming Valley	PA	Short Term Acute	178449
060119	Medical Center of the Rockies	CO	Short Term Acute	570400
370232	Muskogee Community Hospital	OK	Short Term Acute	95636
240053	Park Nicollet Cancer Center	MN	Short Term Acute	104739
100113	Shands Healthcare-New Cancer Hospital	FL	Short Term Acute	476400
100135	TMH Cancer Center	FL	Short Term Acute	51879
260141	UMHC Orthopaedic Institute	MO	Short Term Acute	116168
410010	Women and Infants Hospital Rhode Island	RI	Short Term Acute	140418

The normalized average cost of operation of plant of LEED-certified hospitals which have more than 50000sqf of LEED-certified area is $166.56 and the average of non-LEED hospitals which have the same criteria is $216.63. These values still reflect that 'operation of plant' cost of non-LEED hospitals are lower compared to the LEED-certified ones. However the same problem mentioned in the previous comparison was still valid.

3rd type of comparison

In this comparison the scope is to compare each hospital which the whole building is LEED-certified to the non-LEED hospitals located in the same state and provide same type of health care. The reason of the separation based on the state is because the expenses for operating a facility might differ significantly from state to state, so it makes more sense to divide the hospitals based on the state they are located. The results of the comparison is shown in table 4.19

Table 4.19 Comparison of Total Patient Revenue/Operation of Plant Cost

	State	Type of Care	Total Patient Rev/Opt of plant	LEED Hospital	Total Patient Rev/Opt of plant
1	CO	Short term acute	123.95	Boulder Comm. Foothills Hosp.	83.14
2	MN	Children	206.73	Children's Specialty Center	150.99
3	OR	Short term acute	157.85	Prov. Newberg Med. Center	167.27
4	VA	Short term acute	136.33	Rockingham Memorial Hospital	56.18
5	WI	Psychiatric	16.46	Brown County Community Treatment Center	12.19
6	CO	Short term acute	123.95	Medical Center of the Rockies	172.28
7	OK	Short term acute	169.57	Muskogee Community Hospital	165.19
8	OH	Short term acute	119.65	The Christ Hospital	107.76
9	MI	Short term acute	120.87	Metro Health Hospital	34.94
10	CA	Children	328.00	Children's Hospital and Health	161.87

Table 4.19 Continued

	State	Type of Care	Total Patient Rev/Opt of plant	LEED Hospital	Total Patient Rev/Opt of plant
11	TX	Children	107.59	Dell Children's Medical Center of Center	216.60
12	TN	Short term acute	135.71	Franklin Woods Community Hospital	157.88
13	PA	Short term acute	201.34	Geisinger Patient Pavilion	248.16
		Average	**149.85**	**Average**	**133.42**

Figure 4.2 represents the summary of the results.

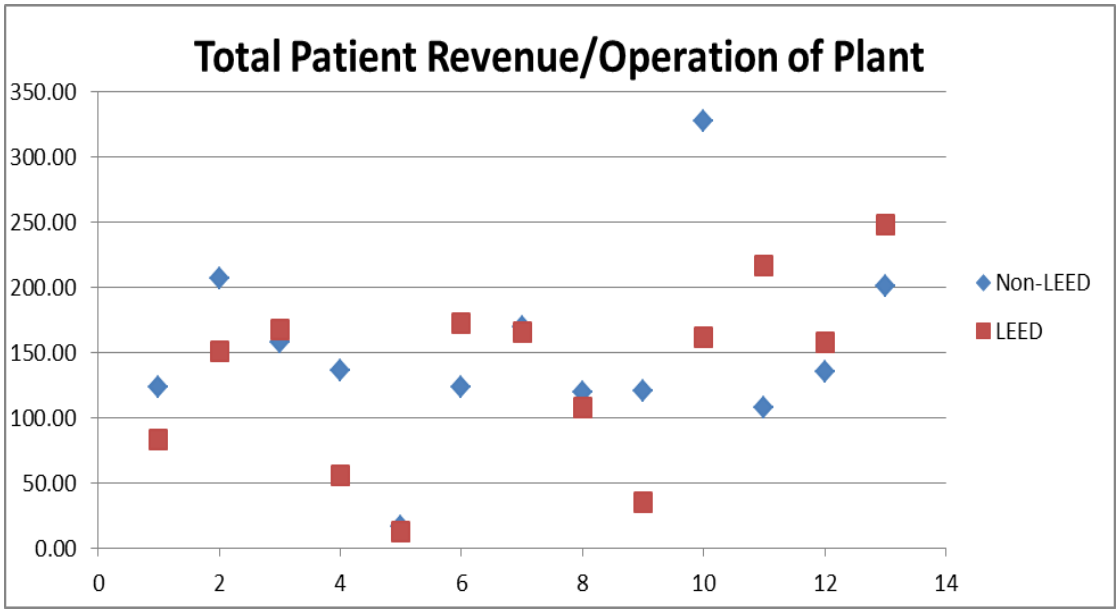

Figure 4.2 Comparison of Total Patient Revenues/Operation of Plant Cost

As it can be seen from table 4.19 and figure 4.2, 8 out of 13 LEED certified hospital are making less revenues per a dollar spent for the operation of plant compared to the average of non-LEED ones and the mean of non-LEED ones are higher than the LEED-

certified ones which is a better indicator for non-LEED ones, but the difference is not significant (p-value = 0.28).

All these three analysis reflect that there is no significant difference between operation of plant costs for non-LEED hospitals and LEED certified hospital. In all of the cases regular hospitals showed a better financial performance.

4th type of comparison

This comparison is used to understand if the operation of plant costs are decreasing compared to the total patient revenue when the LEED certification level is increased. Table 4.20 shows the list of fully LEED certified hospitals with their LEED certification levels and average cost of operation of plant.

Table 4.20 Average Cost of Operation of Plant Based on LEED Certification Level

Provider ID AHD	Project Name	LEED Certification Level	Tot. Ptnt Rev./Oper of Plant
360163	The Christ Hospital	Certified	101.52
230236	Metro Health Hospital	Certified	
053303	Children's Hospital and Health	Certified	
390133	Lehigh Valley Hospital Cedar Crest North	Certified	
050668	Laguna Honda Hospital Replacement Program	Silver	163.06
440184	Franklin Woods Community Hospital	Silver	
390006	Geisinger Patient Pavilion	Silver	
060027	Boulder Community Foothills Hospital	Silver	
243302	Children's Specialty Center	Gold	120.68
380037	Providence Newberg Medical Center	Gold	
490004	Rockingham Memorial Hospital	Gold	
524014	Brown County Community Treatment Center	Gold	
060119	Medical Center of the Rockies	Gold	
370232	Muskogee Community Hospital	Gold	

The average cost of operation of plant is increasing when the level increases from certified to silver, however decreases when it is changed from silver to gold. Therefore it is not logical to accept hypothesis 4 mentioned in the thesis statement section.

4.2.3 Comparison of Profitability of the Hospitals

The second financial indicator which will be compared is the profits of the hospitals. The question is if LEED-certified hospitals are more profitable than the non-LEED ones. For the comparison of the profits of the hospitals, the same four criteria are going to be followed similar to those used in the cost of operation of plant.

The cost values used for this evaluation are the total patient revenues and the total operating expenses. Total operating expenses include all the money spent for maintenance and repairs, medicines, patient treatments, laboratories, etc. The rest of the cost line items can be found in Appendix A. The reason for comparing the profits is to see if the patients prefer LEED-certified hospitals over the non-LEED ones by allowing them gaining more money.

1st type of comparison

Next table shows the money that LEED-certified hospitals are earning when they spend a dollar to run the hospital.

Table 4.21 Total Patient Revenue/Total Operating Expenses of Whole Building LEED-Certified Hospitals

Provider ID AHD	Project Name	Total Pat. Rev./Total Oper. Exp.
360163	The Christ Hospital	2.71
243302	Children's Specialty Center	1.76
230236	Metro Health Hospital	1.95
060027	Boulder Community Foothills Hospital	2.88
053303	Children's Hospital and Health	2.34
453310	Dell Children's Medical Center of Centre	3.34
050668	Laguna Honda Hospital Replacement Program	1.09
380037	Providence Newberg Medical Center	1.99
490004	Rockingham Memorial Hospital	1.70
524014	Brown County Community Treatment Center	1.08
440184	Franklin Woods Community Hospital	4.36
390006	Geisinger Patient Pavilion	4.44
390133	Lehigh Valley Hospital Cedar Crest North	3.94
060119	Medical Center of the Rockies	2.72
370232	Muskogee Community Hospital	2.70
	Average	**2.60**

The average value for the fraction of total patient revenues and total operating expenses for the hospitals reflected in the graph is **2.60**, whereas the value obtained after the same comparison for all of the hospitals in the U.S. is **2.61** which is almost same as the LEED-certified hospitals. These results tell that there is no significant difference between the two hospital groups for this level of comparison.

2nd type of comparison

Table 4.22 Total Patient Revenue/Total Operating Expenses for LEED-Certified Hospitals of 50,000sqf or More Service Area

Provider ID AHD	Project Name	Location (State)	Type of Facility	Sqf of LEED-certified Structure	Tot. Pat. Rev/Tot. Oper. Exp.
360163	The Christ Hospital	OH	Short Term Acute	901000	2.71
243302	Children's Specialty Center	MN	Children	160500	1.76
230236	Metro Health Hospital	MI	Short Term Acute	69224	1.95
500027	Swedish Medical Center	WA	Short Term Acute	270384	2.94
060027	Boulder Community Foothills Hospital	CO	Short Term Acute	153773	2.88
053303	Children's Hospital and Health	CA	Children	272274	2.34
330307	Cayuga Medical Center Southwest Addition	NY	Short Term Acute	110830	1.64
300001	Concord Hospital	NH	Short Term Acute	165000	2.24
453310	Dell Children's Medical Center of Centre	TX	Children	473000	3.34
060011	Denver Health - Pavilion C	CO	Short Term Acute	212215	1.71
390189	Geisinger Gray's Woods Ambulatory	PA	Short Term Acute	61000	2.03
420073	LEXINGTON MEDICAL CENTER MOB-Lexington	SC	Short Term Acute	130000	2.32
200039	Maine General Cancer Center	ME	Short Term Acute	60000	1.83
390116	Mercy Suburban Hospital	PA	Short Term Acute	65000	4.51
380037	Providence Newberg Medical Center	OR	Short Term Acute	176000	1.99
490004	Rockingham Memorial Hospital	VA	Short Term Acute	680000	1.70
524014	Brown County Community Treatment Center	WI	Psychiatric	100491	1.08
490024	Carilion Clinic	VA	Short Term Acute	211080	2.18
500051	Overlake Hospital Medical Center	WA	Short Term Acute	80000	2.47
440184	Franklin Woods Community Hospital	TN	Short Term Acute	238764	4.36
390006	Geisinger Patient Pavilion	PA	Short Term Acute	261554	4.44
390270	Geisinger Wyoming Valley	PA	Short Term Acute	178449	4.45
060119	Medical Center of the Rockies	CO	Short Term Acute	570400	2.72
370232	Muskogee Community Hospital	OK	Short Term Acute	95636	2.70
240053	Park Nicollet Cancer Center	MN	Short Term Acute	104739	1.70
100113	Shands Healthcare-New Cancer Hospital	FL	Short Term Acute	476400	2.58
100135	TMH Cancer Center	FL	Short Term Acute	51879	3.11
260141	UMHC Orthopedic Institute	MO	Short Term Acute	116168	2.33
410010	Women and Infants Hospital Rhode Island	RI	Short Term Acute	140418	1.73
	Average				**2.54**

Table 4.22 represents the average total patient revenue/total operating expenses of LEED certified hospitals which have more than 50,000sqf of LEED certified area. The average value is equal to **2.54**, however the average value of the regular hospitals located all over U.S. with same criteria is **2.61.** The difference between the means is not significant (p-value =0.34), yet regular hospitals are making more profit than the LEED-certified under these circumstances.

3rd type of comparison

Table 4.23 Total Patient Revenue/Total Operating Expenses

	State	Type of Care	Total Patient Rev/Total Oper Exp.	LEED-certified Hospital	Total Patient Rev/Total Oper Exp.
1	CO	Short term acute	2.83	Boulder Community Foothills Hospital	2.88
2	MN	Children	1.87	Children's Specialty Center	1.76
3	OR	Short term acute	2.18	Providence Newberg Medical Center	1.99
4	VA	Short term acute	2.74	Rockingham Memorial Hospital	1.70
5	WI	Psychiatric	0.61	Brown County Community Treatment Center	1.08
6	CO	Short term acute	2.83	Medical Center of the Rockies	2.72
7	OK	Short term acute	3.18	Muskogee Community Hospital	2.70
8	OH	Short term acute	2.93	The Christ Hospital	2.71
9	MI	Short term acute	2.29	Metro Health Hospital	1.95
10	CA	Children	2.40	Children's Hospital and Health	2.34
11	TX	Children	2.11	Dell Children's Medical Center of Centre	3.34
12	CA	Short term acute	4.07	Laguna Honda Hospital Replacement Program	1.09
13	TN	Short term acute	3.49	Franklin Woods Community Hospital	4.36
14	PA	Short term acute	3.57	Geisinger Patient Pavilion	4.44
15	PA	Short term acute	3.57	Lehigh Valley Hospital Cedar Crest North	3.94
		Average	**2.71**	**Average**	**2.60**

Table 4.23 is the comparison of each hospital which is totally LEED-certified to the ones without LEED-certificate at the same state and with the same type of care. The next figure is the summary graphical summary of the table.

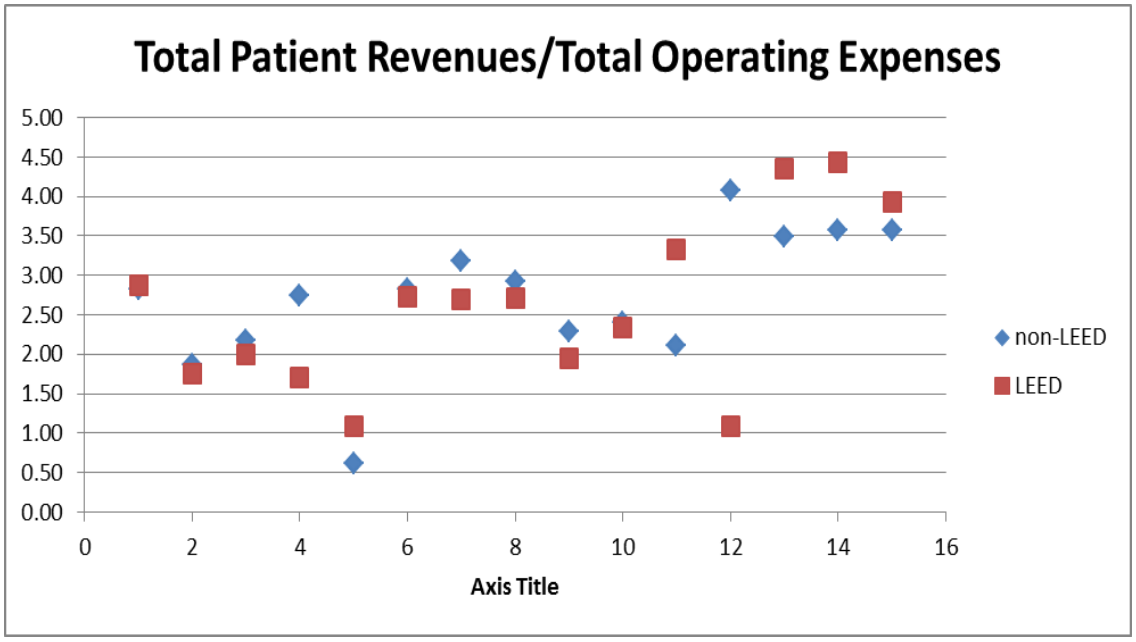

Figure 4.3 Total Patient Revenues/Total Operating Expenses

Table 4.23 and Figure 4.3 summarize that the overall mean of non-LEED hospitals are higher than the LEED-certified ones but not significant (p-value = 0.37) and 9 out of 15 LEED certified hospitals are making less profit compared to the average of non-LEED ones.

All of the three comparisons are giving results that the profits of the LEED certified hospitals is less than the non-LEED hospitals, however the possible reasons of these results will be further explained in the summary and conclusion section of this report.

4th type of comparison

Table 4.24 Average Total Patient Revenue/Total Operating Expenses Values Based on LEED Certification Level

Provider ID AHD	Project Name	LEED Certification Level	Tot. Ptnt. Rev./Tot Oper Exp.)
360163	The Christ Hospital	Certified	2.73
230236	Metro Health Hospital	Certified	
053303	Children's Hospital and Health	Certified	
390133	Lehigh Valley Hospital Cedar Crest North	Certified	
050668	Laguna Honda Hospital Replacement Program	Silver	3.19
440184	Franklin Woods Community Hospital	Silver	
390006	Geisinger Patient Pavilion	Silver	
060027	Boulder Community Foothills Hospital	Silver	
243302	Children's Specialty Center	Gold	1.99
380037	Providence Newberg Medical Center	Gold	
490004	Rockingham Memorial Hospital	Gold	
524014	Brown County Community Treatment Center	Gold	
060119	Medical Center of the Rockies	Gold	
370232	Muskogee Community Hospital	Gold	

Similar to the findings of the cost of operation of plant, this financial indicator is also increasing with the transition from certified to silver, but decreasing when the LEED certification level increases form silver to gold. Therefore it can be said that profitability is not increasing with the higher level of LEED certification.

4.2.4 Comparison of Inpatient Revenues

To understand if the LEED-certified hospitals are preferred more or less than the non-LEED ones, a focus on the inpatient revenues of the hospitals by normalizing it with the

number of beds is required. The value provides the money earned per one bed in one year from the patients spending at least one night at the hospital. The results obtained here will also be used in the next subsection where they aree linked with the results of the HCAHPS.

1st type of comparison

This comparison is again between 15 fully LEED-certified hospitals and all of the regular hospitals in the U.S. Table 4.25 reflects the 'inpatient revenues/number of beds' values for the 15 hospitals.

Table 4.25 Inpatient Revenues/No. of Beds for Fully LEED-Certified Hospitals

Provider ID AHD	Project Name	No. of Beds	Inpatient Revenue $	Inpatient Rev./No. of Beds
360163	The Christ Hospital	451	$819,523,971.00	$1,817,126.32
243302	Children's Specialty Center	202	$416,826,199.00	$2,063,496.03
230236	Metro Health Hospital	208	$233,857,702.00	$1,124,315.88
060027	Boulder Community Foothills Hospital	171	$329,509,856.00	$1,926,958.22
053303	Children's Hospital and Health	272	$841,382,327.00	$3,093,317.38
453310	Dell Children's Medical Center of Centre	167	$408,529,691.00	$2,446,285.57
050668	Laguna Honda Hospital Replacement Program	805	$205,632,599.00	$255,444.22
380037	Providence Newberg Medical Center	40	$46,027,283.00	$1,150,682.08
490004	Rockingham Memorial Hospital	238	$226,282,663.00	$950,767.49
524014	Brown County Community Treatment Center	100	$16,148,385.00	$161,483.85
440184	Franklin Woods Community Hospital	91	$42,650,443.00	$468,686.19
390006	Geisinger Patient Pavilion	427	$1,474,955,176.00	$3,454,227.58
390133	Lehigh Valley Hospital Cedar Crest North	845	$2,388,192,009.00	$2,826,262.73
060119	Medical Center of the Rockies	136	$322,175,852.00	$2,368,940.09
370232	Muskogee Community Hospital	15	$31,701,763.00	$2,113,450.87
	Average			**$1,748,096.30**

The average value for these 15 hospitals is **$1,748,096.30** and the average of all the hospitals in the U.S. is calculated as $**1,267,853.00** by dividing the sum of 'inpatient revenue/no. of beds' values of each hospital to the total number of hospitals located in the U.S. The means look highly different; however there is a need for t-test to see if the difference of the means is significant or not even though there are 15 samples in one group. The results of the t-test are reflected in Table 4.26.

Table 4.26 T-test Results for Comparison of Inpatient Rev/No. of Beds

t-Test: Inpatient Rev./No. of Beds		
	Non-LEED	***LEED-Certified***
Mean	1267852.903	1748096.3
Variance	8.4367E+11	1.0564E+12
Observations	2015	15
Hypothesized Mean Difference	0	
df	14	
t Stat	-1.804289843	
P(T<=t) one-tail	0.046368534	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	0.092737069	
t Critical two-tail	2.144786688	

As it can be seen from Table 4.26 one tailed p-value is equal to 0.046 which shows that with the probability of 95% the inpatient revenues of the fully-LEED certified hospitals will be higher than the non-LEED hospitals, and the difference is significant.

2nd type of comparison

This is the 50000sqf comparison and Table 4.27 is the list of LEED-certified hospitals which have more than 50000sqf of LEED certified area and inpatient revenues.

Table 4.27 LEED-Certified Hospital (area>50,000sqf) Inpatient Revenue/No of Beds Data

Provider ID AHD	Project Name	Sqf. of LEED certified Structure	No. of Beds	Inpatient Revenue $	Inp. Rev/No. of Beds
360163	The Christ Hospital	901000	451	$819,523,971.00	$1,817,126.32
243302	Children's Specialty Center	160500	202	$416,826,199.00	$2,063,496.03
230236	Metro Health Hospital	69224	208	$233,857,702.00	$1,124,315.88
140119	RUMC Orthopedic Ambulatory Building	214553	692	$1,890,125,900.00	$2,731,395.81
500027	Swedish Medical Center	270384	620	$1,379,840,812.00	$2,225,549.70
060027	Boulder Community Foothills Hospital	153773	171	$329,509,856.00	$1,926,958.22
230059	Richard J. Lacks, Sr. Cancer Center	170000	344	$367,513,038.00	$1,068,351.85
053303	Children's Hospital and Health	272274	272	$841,382,327.00	$3,093,317.38
330307	Cayuga Medical Center Southwest Addition	110830	182	$67,570,242.00	$371,265.07
300001	Concord Hospital	165000	205	$314,662,501.00	$1,534,939.03
453310	Dell Children's Medical Center of Centre	473000	167	$408,529,691.00	$2,446,285.57
060011	Denver Health - Pavilion C	212215	352	$592,673,849.00	$1,683,732.53
390189	Geisinger Gray's Woods Ambulatory	61000	68	$27,902,331.00	$410,328.40
420073	LEXINGTON MEDICAL CENTER MOB-Lexington medical Park 2	130000	365	$642,273,645.00	$1,759,653.82
050668	Laguna Honda Hospital Replacement Program	508414	805	$205,632,599.00	$255,444.22
200039	Maine General Cancer Center	60000	236	$216,550,676.00	$917,587.61
390116	Mercy Suburban Hospital	65000	121	$289,652,366.00	$2,393,821.21
380037	Providence Newberg Medical Center	176000	40	$46,027,283.00	$1,150,682.08
490004	Rockingham Memorial Hospital	680000	238	$226,282,663.00	$950,767.49
520009	St. Elizabeth Hospital - South Addition	74978	205	$141,698,134.00	$691,210.41
524014	Brown County Community Treatment Center	100491	100	$16,148,385.00	$161,483.85
490024	Carilion Clinic	211080	775	$1,008,458,948.00	$1,301,237.35
500051	Overlake Hospital Medical Center	80000	307	$512,465,498.00	$1,669,268.72

Table 4.27 Continued

Provider ID AHD	Project Name	Sqf. of LEED certified Structure	No. of Beds	Inpatient Revenue $	Inp. Rev/No. of Beds
.	Franklin Woods Community Hospital	238764	91	$42,650,443.00	$468,686.19
390006	Geisinger Patient Pavilion	261554	427	$1,474,955,176.00	$3,454,227.58
390270	Geisinger Wyoming Valley	178449	242	$492,453,419.00	$2,034,931.48
390133	Lehigh Valley Hospital Cedar Crest North	327605	845	$2,388,192,009.00	$2,826,262.73
060119	Medical Center of the Rockies	570400	136	$322,175,852.00	$2,368,940.09
370232	Muskogee Community Hospital	95636	15	$31,701,763.00	$2,113,450.87
240053	Park Nicollet Cancer Center	104739	368	$415,689,351.00	$1,129,590.63
100113	Shands Healthcare-New Cancer Hospital	476400	870	$1,711,825,698.00	$1,967,615.74
100135	TMH Cancer Center	51879	603	$768,769,181.00	$1,274,907.43
260141	UMHC Orthopaedic Institute	116168	383	$588,734,028.00	$1,537,164.56
410010	Women and Infants Hospital Rhode Island	140418	247	$447,984,846.00	$1,813,703.83
	Average				**$1,609,932.34**

The mean value of 'inpatient revenues/no. of beds' for LEED-certified hospitals that meet the 50,000sqf criteria is **$1,609,932.34**, whereas for the non-LEED ones this value is equal to **$1,100,560.00**. The difference looks relatively high, however to understand if it is significant or not, a t-test is applied for the means of the two groups. The results of the t-test are reflected in the next table.

Table 4.28 T-test Results for Inpatient Revenue/No of Beds Comparison

t-Test: Inpatient Rev/No of Beds		
	non-LEED	LEED-Certified
Mean	1100559.551	1609932.344
Variance	8.37442E+11	6.89325E+11
Observations	2464	34
Hypothesized Mean Difference	0	
df	34	
t Stat	-3.547750181	
P(T<=t) one-tail	0.000579008	
t Critical one-tail	1.690924255	
P(T<=t) two-tail	0.001158017	
t Critical two-tail	2.032244509	

The p-value is equal to 0.000579 which shows that the mean value of inpatient revenue per bed of the LEED-certified hospitals with 50,000sqf or more service area is higher than the non-LEED ones with the possibility of almost 100%. This fact aligns with the general finding of the research identified in the literature review.

3rd type of comparison

As mentioned earlier this comparison is the one between each of the fully LEED-certified hospitals to the ones located at the same state with the same type of care. Table

4.29 shows the averages of the hospitals by state and care type for the inpatient revenues per bed.

Table 4.29 Inpatient Revenues/No of Beds Comparison by State and Care Type

	State	Type of Care	Inp Rev/No. of Beds(non-LEED	LEED-Certified Hospital	Inp Rev/No. of Beds(LEED)
1	CO	Short term acute	$1,493,156.82	Boulder Community Foothills Hospital	$1,926,958.22
2	MN	Children	$2,048,054.18	Children's Specialty Center	$2,063,496.03
3	OR	Short term acute	$1,335,369.59	Providence Newberg Medical Center	$1,150,682.08
4	VA	Short term acute	$964,119.25	Rockingham Memorial Hospital	$950,767.49
5	WI	Psychiatric	$294,183.96	Brown County Community Treat Cent.	$161,483.85
6	CO	Short term acute	$1,493,156.82	Medical Center of the Rockies	$2,368,940.09
7	OK	Short term acute	$1,036,051.51	Muskogee Community Hospital	$2,113,450.87
8	OH	Short term acute	$999,370.65	The Christ Hospital	$1,817,126.32
9	MI	Short term acute	$938,601.41	Metro Health Hospital	$1,124,315.88
10	CA	Children	$2,586,497.90	Children's Hospital and Health	$3,093,317.38
11	TX	Children	$2,450,061.25	Dell Children's Medical Center	$2,446,285.57
12	CA	Short term acute	$2,350,392.99	Laguna Honda Hospital Repl. Prog.	$255,444.22
13	TN	Short term acute	$849,905.53	Franklin Woods Community Hospital	$468,686.19
14	PA	Short term acute	$1,499,473.54	Geisinger Patient Pavilion	$3,454,227.58
15	PA	Short term acute	$1,499,473.54	Lehigh Valley Hospital Cedar Crest	$2,826,262.73
		Average	**$1,455,857.93**	**Average**	**$1,748,096.30**

In the next figure the graphical view of the previous table is reflected.

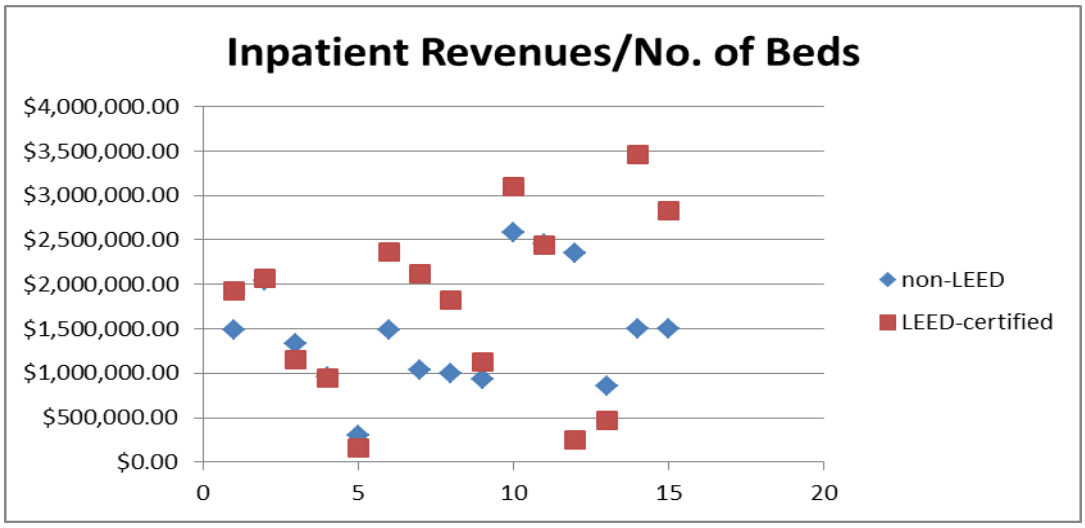

Figure 4.4 Inpatient Revenues/No of Beds Comparison by State and Care Type

9 out of 15 fully LEED-certified hospitals have higher inpatient revenues per bed compared to the hospitals located at the same state and which have same type of care. The p-value calculated by comparing the means of the two groups is 0.19, and shows that the difference is not significant, however sample sizes of the both groups are 15 and this number is not enough to have trustable t-test results.

All of the three comparisons show that inpatient revenues per bed gained by the LEED certified hospitals are higher than the non-LEED ones. This verifies what the literature says about the hospital preference of patients, because most of the previous research on this topic claims that sustainably designed hospitals are more patient-friendly places, that in-turn increase patient and staff satisfaction.

4th type of comparison

Table 4.30 Average Inpatient Revenues/No. of Beds Based on LEED Certification Level

Provider ID AHD	Project Name	LEED Certification Level	Inp. Rev/No. of Beds
360163	The Christ Hospital	Certified	$2,215,255.58
230236	Metro Health Hospital	Certified	
053303	Children's Hospital and Health	Certified	
390133	Lehigh Valley Hospital Cedar Crest North	Certified	
050668	Laguna Honda Hospital Replacement Program	Silver	$1,526,329.05
440184	Franklin Woods Community Hospital	Silver	
390006	Geisinger Patient Pavilion	Silver	
060027	Boulder Community Foothills Hospital	Silver	
243302	Children's Specialty Center	Gold	$1,468,136.73
380037	Providence Newberg Medical Center	Gold	
490004	Rockingham Memorial Hospital	Gold	
524014	Brown County Community Treatment Center	Gold	
060119	Medical Center of the Rockies	Gold	
370232	Muskogee Community Hospital	Gold	

The inpatient revenue per bed is inversely proportional to the LEED-certification level according to the findings reflected in Table 4.30. This concludes that none of the financial indicators are showing a consistent change with different level of LEED certification.

4.3 Intersection of HCAHPS and Inpatient Revenue per Bed

The relationship between the findings of the HCAHPS and the results of the inpatient revenues per bed is the focus of this section. As the HCAHPS is filled out by the patients who spend at least one night at the health care facility, it makes sense to find the relationship by using inpatient revenues. The last two questions of the survey were ‘how

do patients rate the hospital overall?' and 'would patients recommend the hospital to friends and family?' that reflect the patients' generalized opinion about the hospital. If the patients were not satisfied with the hospital, they would give lower ratings and they would not recommend it to family or friends. According to the outcomes of the last two questions, LEED-certified hospitals should have higher patient revenues per bed. In other words, the results of the survey should satisfy the findings of the financial indicator 'inpatient revenues per bed'.

To start the comparison process, the first set of data needed is the average scores of non-LEED hospitals for the above mentioned questions and the mean value of inpatient revenue per bed of non-LEED hospitals that have more than 50,000sqf of service area. Table 4.31 gives information about these values.

Table 4.31 Average of non-LEED Hospitals for Rating and Recommendation Question in the HCAHPS Survey and Inpatient Revenues per Bed

	Rating	Recommend	Inpatient Rev/No. of Beds
Average of Non- LEED Hospitals	59%	64%	$1,100,560.00

Then there is a need to determine the LEED-certified hospitals which have more than 50,000sqf of LEED-certified area, have a financial value in the Inpatient Revenue column and at the same time it should be listed also in the HCAHPS database. There are 29 LEED-certified hospitals which meet these requirements; however 9 of these have lower scores for the last two questions, and more than half of these 9 hospitals have

lesser or similar inpatient revenues per bed to the non-LEED ones. Table 4.32 shows these 9 hospitals.

Table 4.32 9 LEED-Certified Hospitals Which Have Lower Rating or Recommendation Score than the non-LEED Hospitals

Provider ID AHD	Project Name	Rating	Recommend	Inpatient Rev/No. of Beds(LEED)
060011	Denver Health - Pavilion C	0.59	0.62	$1,683,732.53
200039	Maine General Cancer Center	0.51	0.6	$917,587.61
390116	Mercy Suburban Hospital	0.37	0.44	$2,393,821.21
490004	Rockingham Memorial Hospital	0.55	0.61	$950,767.49
520009	St. Elizabeth Hospital - South Addition	0.63	0.68	$691,210.41
390270	Geisinger Wyoming Valley	0.52	0.62	$2,034,931.48
240053	Park Nicollet Cancer Center	0.52	0.65	$1,129,590.63
100135	TMH Cancer Center	0.57	0.67	$1,274,907.43
260141	UMHC Orthopaedic Institute	0.56	0.7	$1,537,164.56

20 of 29 hospitals have better rating and recommendation scores compared to the regular hospitals and they are shown in the next table.

Table 4.33 Rating, Recommendation score and Inpatient Rev. per Bed of LEED-Certified Hospitals

Provider ID AHD	Project Name	Rating	Recommend	Inpatient Rev/No. of Beds(LEED)
360163	The Christ Hospital	78%	85%	$1,817,126.32
230236	Metro Health Hospital	75%	79%	$1,124,315.88
140119	RUMC Orthopedic Ambulatory Building	64%	74%	$2,731,395.81
500027	Swedish Medical Center	64%	76%	$2,225,549.70
060027	Boulder Community Foothills Hospital	63%	71%	$1,926,958.22
230059	Richard J. Lacks, Sr. Cancer Center	65%	70%	$1,068,351.85
330307	Cayuga Medical Center Southwest Addition	63%	66%	$371,265.07
300001	Concord Hospital	72%	80%	$1,534,939.03

Table 4.33 Continued

Provider ID AHD	Project Name	Rating	Recommend	Inpatient Rev/No. of Beds(LEED)
390189	Geisinger Gray's Woods Ambulatory	64%	74%	$410,328.40
420073	Lexington Medical Center Mob- Lexington medical Park 2	69%	75%	$1,759,653.82
380037	Providence Newberg Medical Center	70%	77%	$1,150,682.08
490024	Carilion Clinic	64%	73%	$1,301,237.35
500051	Overlake Hospital Medical Center	68%	76%	$1,669,268.72
440184	Franklin Woods Community Hospital	73%	79%	$468,686.19
390006	Geisinger Patient Pavilion	71%	79%	$3,454,227.58
390133	Lehigh Valley Hospital Cedar Crest North	64%	75%	$2,826,262.73
060119	Medical Center of the Rockies	80%	83%	$2,368,940.09
370232	Muskogee Community Hospital	75%	83%	$2,113,450.87
100113	Shands Healthcare-New Cancer Hospital	62%	75%	$1,967,615.74
410010	Women and Infants Hospital Rhode Island	72%	84%	$1,813,703.83

All of the hospitals listed in the table 4.33 have better overall patient evaluation scores compared to the average of the non-LEED hospitals. The inpatient revenues per bed are actually empowering the results of the survey. Only 4 hospitals which have got higher scores from the survey have lower inpatient revenues per bed compared to the U.S average. The remaining 16 hospitals are providing significantly higher inpatient revenues per bed. Therefore it can be said that the results of the survey are providing realistic outcomes that can be used safely in future research.

5. CONCLUSIONS

The literature review associated with this thesis research documented past studies that LEED-certified hospitals performed better than regular (non-LEED) hospitals regarding patient satisfaction and financial indicators. The findings obtained after the data analysis agree with the claims in some cases, whereas for the rest of the cases it contradicts with what the researchers expected. However, these contradictions might be caused by the assumptions that the author made, by the methods used to normalize the financial data, or by the errors in the cost database.

From the survey, results of 9 questions were reflected in the HCAPHS database which gives idea about nurses' performances, doctors' performances, indoor environmental quality, and overall satisfaction about the hospital. Based on the results of the comparison of LEED-certified and non-LEED-certified hospital the below mentioned outcomes were obtained.

- The sustainable design features are usually increasing the performance of the nurses; however they do not have too much impact on the doctors. The reason may be that the nurses are spending most of their days with visiting patients' room or by walking the facility that allows them to get impacted by the building features, whereas the doctors mostly stay in their private rooms besides the times they visit the patients in patient rooms. As such, doctors may not be exposed to and impacted as much by the indoor environment.

- Even though patients are the most stressed group of occupants at the hospitals, they still get affected by the sustainable practices applied at the hospitals. Being in a less stressful, brighter and green environment may let their stress decrease and helps to lower their pains. In addition to these, better nurse performance may also increase their satisfaction, because whenever the hospital staff communicates well with the patients, they feel like their well-being is important to the nurses which in-turn may result in happier patients.
- There is no significant difference between the noise levels inside the patients' rooms of two types of hospitals during night time. As it is quite well-known, hospitals are loud places because of all the people, activity, equipment sounds, sirens, etc. Therefore LEED certified hospitals design the walls of the patients' rooms with the optimum thickness and also some of them place green roof on the top floor to reduce the transfer of noise to the upper floors from the outside. In is unclear, but it appears that these practices seem not to be working so well.
- When it comes to cleanness of the bathrooms, most of the patients who filled in the survey after staying at a non-LEED hospital told that their bathroom was always clean; however the percent for the answer of this question is lower at the LEED-certified hospitals. Reasons of this situation might be first of all the less amount of water usage for cleaning at the sustainable hospitals; they usually prefer special mops which do not require water. It removes all the dirt and germs, but they do not leave behind a surface which shines like sun. The second reason might be the usage of environmentally harmful chemicals during the cleaning

process at the non-LEED hospitals. These products lead to a clean appearance and make the bathrooms smell fresher. The products used at the LEED-certified ones clean nearly the same; however they do not incorporate additives harmful to the environment that can make the bathrooms smell extra fresh.

- Overall the LEED-certified hospitals have significantly higher ratings and recommendation levels compared to the regular hospitals. One thing about the survey is that it does not have any questions directly related to the evaluation of building fixtures like how are their satisfaction/stress levels impacted by the hospital's indoor environmental quality, or was the room where you stayed designed in an optimum way to satisfy your needs. The survey is mostly focusing on understanding how the staff did during the treatment process like 'did the nurses help you as soon as possible', 'did the doctors inform you about the medicine that he/she is giving'. At the end there are two questions to rate and recommend the hospital and these ones gives indirect idea about the patients thought related to the hospital. If the people who are preparing this survey added more questions about the building, it would provide better results for the comparison of two groups of hospitals.

For the comparison of financial indicators, 3 financial values were investigated in this thesis. The first one is the 'total patient revenue/operation of plant' that gives an idea about the gained patient revenue compared to the operation of plant costs. The second one is the 'total patient revenue/total operating expenses' a measure that basically tells

the profitability of hospitals. The third one is the 'total inpatient revenue/number of beds' that measures inpatient revenue made in a year for each bed.

The author defined 4 different criteria for the comparison of these values. The first three of the four criteria is the comparison of LEED-certified hospitals to the non-LEED ones, whereas the last one is the comparison between four different LEED-certification levels. The results of these comparisons could be explained by the following:

- LEED-certified hospitals have higher cost of operation of plant and lower profitability compared to the regular hospitals. This is in conflict to the research mentioned in the literature review. However there are couples of reasons that may cause this issue. One of them is the errors in the CMS database. A significant number of hospitals have unrealistic values such as $100 or $200 for the operation of plant cost for 60,000-70,000sqf of facility which does not make much sense. When the cost of operation of plant used is divided by total patient revenues, the numbers obtained were way beyond the logical limit for this comparison. Obviously some of the hospitals filled this cost reports just for the sake of filling them. A solution to this problem might be provided by CMS where they can filter the data to eliminate the unrealistic values. The second possible cause of the unwanted results from this comparison is the large amount of missing data in the CMS cost reports. The reports are designed to acquire very specific details about the health care facility starting from the highest level and continuing to the lowest. Before looking at the values in the database, an observation regarding the reports was made to compare the partially LEED-

certified hospitals department by department to the regular hospitals' department, because these hospitals had LEED certification for just a couple of departments. In the CMS reports there are columns for the hospitals to report their square footage, total number of patients, total patient revenues, and total operating expenses for each department. However none of the hospitals did this. They completed the rows only for the total values of these line items. Therefore it was impossible to have a fair comparison between the partially LEED-certified hospitals and all of the hospitals in the U.S. The 15 fully LEED certified hospitals are the only ones that might be compared to the U.S. average in a fair way besides the errors in the operation of plant line item. The body of 15 hospitals is not enough to have a trustable t-test comparison results.

- The increased level of LEED certification is not improving the financial values for operation of plant or total operating expenses. However in these cases the sample sizes were very small. This study should be repeated in the future when there are more LEED-certified hospitals.
- One of the most reasonable comparisons is the one for the 'inpatient revenue/number of beds', because total inpatient revenues are highly correlated with the number of beds and the inpatient revenues in the CMS did not look so skeptical. The results show that LEED-certified hospitals are making more inpatient revenue per one bed in one year and this aligns with the outcomes of the HCAHPS survey.

Even though the non-LEED hospitals are performing better when it comes to financial indicators except the inpatient revenue per bed, the doubts in the CMS database may taint the results of this research. However, it is reasonable to say that the hospitals that received higher HCAHPS scores are making more inpatient revenue per bed per year, and this outcome provides insight into patient preference when they pick a hospital to receive a treatment.

If the hospitals reported to CMS more clearly and fill out the forms completely, it would result in a much more fair comparison and probably altered the results as reported.

6. FUTURE RESEARCH

Sustainable design is a very serious issue to focus on for having a healthier and cleaner environment where the natural resources are not consumed as if they are limitless. Even though the results of this study is not proving the financial benefits of the LEED practices, the author believes that operating sustainable designed facilities can be cheaper than those non-LEED hospitals. However the analysis of the data set regarding this research does not fully support such a claim. As such, hospital organizations should gather more accurate data regarding plant operation, repair and maintenance costs, total operating expenses, square feet and total patient days for each department to possibly prove this hypothesis.

REFERENCES

Badrick, T. (2010). "Healthcare waste management." *Medical Tourism Magazine,* 52(15), 90-92. (February, 6, 2012).

Buckley, D., and Smyth, B. (2007). "Taking the LEED." *Behavioral Healthcare,* 27(9), 30-33. (February, 6, 2012).

Buffaloe, B. (2009). "What is LEED?" <http://missourifamilies.org/quick/housingqa/housingqa42.htm> (January, 15, 2012).

Bush, H. (2008). "The path to going green. (Cover story)." *H&HN: Hospitals & Health Networks,* 82(8), 26-32. (January, 20, 2012)

Cassidy, R. (2003). "Why a white paper on sustainability?" *Building Design and Construction,* 10(5), 1-48. (January, 20, 2012).

Devlin, A. S., and Arneill, A. B. (2003). "Health care environments and patient outcomes." *Environment & Behavior,* 35(5), 665-694. (March, 11, 2012).

Ecomii. (2012). "Sustainable design." <http://www.ecomii.com/ecopedia/sustainable-design> (January, 12, 2012).

EIA. (2011). "Energy use in commercial buildings." <http://www.eia.gov/energyexplained/index.cfm?page=us_energy_commercial#tab2> (January, 10, 2012).

EPA. (2007). “Indoor Air Quality: Material Selection”, *EPA*, <http://www.epa.gov/region9/waste/p2/pdf/IAQFinalOct12.pdf> (January, 5, 2012).

Ferenc, J. (2010). "Going Greener." *Health Facilities Management,* 23(12), 24-28. (February, 9, 2012).

Fischer, G. (2008). “The Green Patient Room: A 3-D Experience in Every Context”, *The McMorrow*, <http://mcmorrowreport.com/hfm/articles/greenroom.asp> (January, 18, 2012).

Green Roofs for Healthy Cities. (2012). "Green roof benefits." <http://www.greenroofs.org/index.php/about-green-roofs/2577-aboutgrnroofs> (March, 9, 2012).

Guenther, R., and Vittori, G. (2007). *Sustainable Healthcare Architecture,* John Wiley & Sons, New Jersey. (March, 11, 2012).

Hampton, T. (2007). "Hospitals and clinics go green for health of patients and environment." *JAMA: Journal of the American Medical Association,* 298(14), 1625-1629. (January, 25, 2012).

Joseph, A., Keller, A., Quan, X., Quist, C. (2010). “An open-source searchable database to assess the impact of environmental strategies on outcomes in healthcare facilities”, *USGBC*, <https://www.usgbc.org/ShowFile.aspx?DocumentID=9535> (February, 5, 2012).

Kaushal, V., and Gupta, A. K. (2004). "Environmental control including ventilation in hospitals." *JK Science,* 64(6), 229-232. (January, 25, 2012).

Lennon, M. (2010). "Systems for upgrading the hospital environment." <http://www.healthcarebuildingideas.com/article/systems-upgrading-hospital-environment?page=show> (January, 18, 2012).

Munters Corporation. (2009). "Cost-Effective Climate Control for Hospitals", *Munters Corporation*, <http://webdh.munters.com/webdh/BrochureUploads/Application%20Guide-%20Hospitals.pdf> (March, 9, 2012).

NRDC. (2011). "LEED certification information." <http://www.nrdc.org/buildinggreen/leed.asp> (January, 10, 2012).

Pearson, A., and Short, M. (2011). "Effects of Noise Pollution on Healthcare Staff and Patients", <http://www.soundmask.com.au/pdf/2011whitepaper.pdf> (January, 12, 2012).

Riley, D., Freihaut, J., Bahnfleth, W., Karapatyan, Z. (2004) "Indoor air quality management and infection control in health care facility construction." <http://www.engr.psu.edu/iec/publications/papers/indoor_air_quality.pdf> (February, 9, 2012).

Roberts, G. L. (2011). "Shades of green." *Health Facility Management,* 24(11), 45-50. (March, 12, 2012).

Rostenberg, B. (2011). "Sustainability and evidence: The intersection of evidence-based design and sustainability." <http://www.worldhealthdesign.com/Sustainability-and-Evidence.aspx> (January, 13, 2012).

Saint Alphonsus. (2011). "Top 10 list of evidence based design feature." <http://www.saintalphonsus.org/CenterforAdvancedHealing_design.html> (January, 10, 2012).

Sattler, B. (2007). "Going green with healthcare design.", *The American Nurse,* 39(2), 7. (January 12, 2012).

Taddonio, K. (2011). "Hospitals Save Costs with Water Efficiency", *U.S. Department of Energy*, <http://apps1.eere.energy.gov/buildings/publications/pdfs/alliances/hea_water_efficiency_fs.pdf> (January, 12, 2012).

USGBC. (2011). "What LEED delivers?" <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1990> (January, 15, 2012).

Wilhelm, M. (2005). "Green Building Specifics: Costs, Benefits and Case Studies", *U.S Green Building Council*,

<http://wsppn.org/pdf/hospital/10%20Green%20Building%201%20(AZ).pdf>, (January, 20, 2012).

World Water Council. (2011). "Water crisis." <http://worldwatercouncil.org/index.php?id=25> (March, 2, 2012).

APPENDIX A

HCAHPS Survey

SURVEY INSTRUCTIONS

- You should only fill out this survey if you were the patient during the hospital stay named in the cover letter. Do not fill out this survey if you were not the patient.
- Answer all the questions by checking the box to the left of your answer.
- You are sometimes told to skip over some questions in this survey. When this happens you will see an arrow with a note that tells you what question to answer next, like this:

  ☐ Yes
  ☑ No → *If No, Go to Question 1*

You may notice a number on the survey. This number is ONLY used to let us know if you returned your survey so we don't have to send you reminders.
Please note: Questions 1-22 in this survey are part of a national initiative to measure the quality of care in hospitals. OMB #0938-0981

Please answer the questions in this survey about your stay at the hospital named on the cover letter. Do not include any other hospital stays in your answers.

YOUR CARE FROM NURSES

1. **During this hospital stay, how often did nurses treat you with courtesy and respect?**

   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always

2. **During this hospital stay, how often did nurses listen carefully to you?**

   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always

3. **During this hospital stay, how often did nurses explain things in a way you could understand?**

   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always

4. **During this hospital stay, after you pressed the call button, how often did you get help as soon as you wanted it?**

   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always
   [9] ☐ I never pressed the call button

YOUR CARE FROM DOCTORS

5. During this hospital stay, how often did doctors treat you with courtesy and respect?

   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always

6. During this hospital stay, how often did doctors listen carefully to you?

   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always

7. During this hospital stay, how often did doctors explain things in a way you could understand?

   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always

THE HOSPITAL ENVIRONMENT

8. During this hospital stay, how often were your room and bathroom kept clean?

   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always

9. During this hospital stay, how often was the area around your room quiet at night?

   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always

YOUR EXPERIENCES IN THIS HOSPITAL

10. During this hospital stay, did you need help from nurses or other hospital staff in getting to the bathroom or in using a bedpan?

    [1] ☐ Yes
    [2] ☐ No ➔ If No, Go to Question 12

11. How often did you get help in getting to the bathroom or in using a bedpan as soon as you wanted?

    [1] ☐ Never
    [2] ☐ Sometimes
    [3] ☐ Usually
    [4] ☐ Always

12. During this hospital stay, did you need medicine for pain?

    [1] ☐ Yes
    [2] ☐ No ➔ If No, Go to Question 15

13. During this hospital stay, how often was your pain well controlled?

    [1] ☐ Never
    [2] ☐ Sometimes
    [3] ☐ Usually
    [4] ☐ Always

14. During this hospital stay, how often did the hospital staff do everything they could to help you with your pain?

    [1] ☐ Never
    [2] ☐ Sometimes
    [3] ☐ Usually
    [4] ☐ Always

15. During this hospital stay, were you given any medicine that you had not taken before?
    - [1] ☐ Yes
    - [2] ☐ No ➔ If No, Go to Question 18

16. Before giving you any new medicine, how often did hospital staff tell you what the medicine was for?
    - [1] ☐ Never
    - [2] ☐ Sometimes
    - [3] ☐ Usually
    - [4] ☐ Always

17. Before giving you any new medicine, how often did hospital staff describe possible side effects in a way you could understand?
    - [1] ☐ Never
    - [2] ☐ Sometimes
    - [3] ☐ Usually
    - [4] ☐ Always

WHEN YOU LEFT THE HOSPITAL

18. After you left the hospital, did you go directly to your own home, to someone else's home, or to another health facility?
    - [1] ☐ Own home
    - [2] ☐ Someone else's home
    - [3] ☐ Another health facility ➔ If Another, Go to Question 21

19. During this hospital stay, did doctors, nurses or other hospital staff talk with you about whether you would have the help you needed when you left the hospital?
    - [1] ☐ Yes
    - [2] ☐ No

20. During this hospital stay, did you get information in writing about what symptoms or health problems to look out for after you left the hospital?
    - [1] ☐ Yes
    - [2] ☐ No

OVERALL RATING OF HOSPITAL

Please answer the following questions about your stay at the hospital named on the cover letter. Do not include any other hospital stays in your answers.

21. Using any number from 0 to 10, where 0 is the worst hospital possible and 10 is the best hospital possible, what number would you use to rate this hospital during your stay?
    - [0] ☐ 0 Worst hospital possible
    - [1] ☐ 1
    - [2] ☐ 2
    - [3] ☐ 3
    - [4] ☐ 4
    - [5] ☐ 5
    - [6] ☐ 6
    - [7] ☐ 7
    - [8] ☐ 8
    - [9] ☐ 9
    - [10] ☐ 10 Best hospital possible

22. **Would you recommend this hospital to your friends and family?**
    - [1] ☐ Definitely no
    - [2] ☐ Probably no
    - [3] ☐ Probably yes
    - [4] ☐ Definitely yes

ABOUT YOU

There are only a few remaining items left.

23. **In general, how would you rate your overall health?**
    - [1] ☐ Excellent
    - [2] ☐ Very good
    - [3] ☐ Good
    - [4] ☐ Fair
    - [5] ☐ Poor

24. **What is the highest grade or level of school that you have completed?**
    - [1] ☐ 8th grade or less
    - [2] ☐ Some high school, but did not graduate
    - [3] ☐ High school graduate or GED
    - [4] ☐ Some college or 2-year degree
    - [5] ☐ 4-year college graduate
    - [6] ☐ More than 4-year college degree

25. **Are you of Spanish, Hispanic or Latino origin or descent?**
    - [1] ☐ No, not Spanish/Hispanic/Latino
    - [2] ☐ Yes, Puerto Rican
    - [3] ☐ Yes, Mexican, Mexican American, Chicano
    - [4] ☐ Yes, Cuban
    - [5] ☐ Yes, other Spanish/Hispanic/Latino

26. **What is your race? Please choose one or more.**
    - [1] ☐ White
    - [2] ☐ Black or African American
    - [3] ☐ Asian
    - [4] ☐ Native Hawaiian or other Pacific Islander
    - [5] ☐ American Indian or Alaska Native

27. **What language do you mainly speak at home?**
    - [1] ☐ English
    - [2] ☐ Spanish
    - [3] ☐ Chinese
    - [4] ☐ Russian
    - [5] ☐ Vietnamese
    - [6] ☐ Some other language (please print): _____

THANK YOU

Please return the completed survey in the postage-paid envelope.

[NAME OF SURVEY VENDOR OR SELF-ADMINISTERING HOSPITAL]

[RETURN ADDRESS OF SURVEY VENDOR OR SELF-ADMINISTERING HOSPITAL]

Sample Initial Cover Letter for the HCAHPS Survey

[HOSPITAL LETTERHEAD]

[SAMPLED PATIENT NAME]
[ADDRESS]
[CITY, STATE ZIP]

Dear [SAMPLED PATIENT NAME]:

Our records show that you were recently a patient at [NAME OF HOSPITAL] and discharged on [DISCHARGE DATE]. Because you had a recent hospital stay, we are asking for your help. This survey is part of an ongoing national effort to understand how patients view their hospital experience. Hospital results will be publicly reported and made available on the Internet at www.hospitalcompare.hhs.gov. These results will help consumers make important choices about their hospital care, and will help hospitals improve the care they provide.

Questions 1-22 in the enclosed survey are part of a national initiative sponsored by the United States Department of Health and Human Services to measure the quality of care in hospitals. Your participation is voluntary and will not affect your health benefits.

We hope that you will take the time to complete the survey. Your participation is greatly appreciated. After you have completed the survey, please return it in the pre-paid envelope. Your answers may be shared with the hospital for purposes of quality improvement. [*OPTIONAL*: You may notice a number on the survey. This number is ONLY used to let us know if you returned your survey so we don't have to send you reminders.]

If you have any questions about the enclosed survey, please call the toll-free number 1-800-xxx-xxxx. Thank you for helping to improve health care for all consumers.

Sincerely,

[HOSPITAL ADMINISTRATOR]
[HOSPITAL NAME]

Note: The OMB Paperwork Reduction Act language must be included in the mailing. This language can be either in the cover letter or on the front or back of the questionnaire. The exact OMB Paperwork Reduction Act language is included in this appendix. Please refer to the Mail Only, and Mixed Mode sections, for specific letter guidelines.

Sample Follow-up Cover Letter for the HCAHPS Survey

[HOSPITAL LETTERHEAD]

[SAMPLED PATIENT NAME]
[ADDRESS]
[CITY, STATE ZIP]

Dear [SAMPLED PATIENT NAME]:

Our records show that you were recently a patient at [NAME OF HOSPITAL] and discharged on [DATE OF DISCHARGE]. Approximately three weeks ago we sent you a survey regarding your hospitalization. If you have already returned the survey to us, please accept our thanks and disregard this letter. However, if you have not yet completed the survey, please take a few minutes and complete it now.

Because you had a recent hospital stay, we are asking for your help. This survey is part of an ongoing national effort to understand how patients view their hospital experience. Hospital results will be publicly reported and made available on the Internet at www.hospitalcompare.hhs.gov. These results will help consumers make important choices about their hospital care, and will help hospitals improve the care they provide.

Questions 1-22 in the enclosed survey are part of a national initiative sponsored by the United States Department of Health and Human Services to measure the quality of care in hospitals. Your participation is voluntary and will not affect your health benefits. Please take a few minutes and complete the enclosed survey. After you have completed the survey, please return it in the pre-paid envelope. Your answers may be shared with the hospital for purposes of quality improvement. [*OPTIONAL*: You may notice a number on the survey. This number is ONLY used to let us know if you returned your survey so we don't have to send you reminders.]

If you have any questions about the enclosed survey, please call the toll-free number 1-800-xxx-xxxx. Thank you again for helping to improve health care for all consumers.

Sincerely,

[HOSPITAL ADMINISTRATOR]
[HOSPITAL NAME]

Note: The OMB Paperwork Reduction Act language must be included in the mailing. This language can be either in the cover letter or on the front or back of the questionnaire. The exact OMB Paperwork Reduction Act language is included in this appendix. Please refer to the Mail Only, and Mixed Mode sections, for specific letter guidelines.

OMB Paperwork Reduction Act Language

The OMB Paperwork Reduction Act language must be included in the survey mailing. This language can be either in the cover letter or on the front or back of the questionnaire. The following is the language that must be used:

English Version

"According to the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information collection is 0938-0981. The time required to complete this information collected is estimated to average 7 minutes per response for questions 1-22 on the survey, including the time to review instructions, search existing data resources, gather the data needed, and complete and review the information collection. If you have any comments concerning the accuracy of the time estimate(s) or suggestions for improving this form, please write to: Centers for Medicare & Medicaid Services, 7500 Security Boulevard, C1-25-05, Baltimore, MD 21244-1850."

APPENDIX B

05-04 FORM CMS-2552-96 3690 (Cont.)

RECLASSIFICATION AND ADJUSTMENT OF TRIAL BALANCE OF EXPENSES | PROVIDER NO.: _____ | PERIOD: FROM _____ TO _____ | WORKSHEET A

		COST CENTER DESCRIPTIONS (omit cents)	SALARIES	OTHER	TOTAL (col. 1 + col. 2)	RECLASSIFI-CATIONS	RECLASSIFIED TRIAL BALANCE (col. 3 ± col. 4)	ADJUSTMENTS	NET EXPENSES FOR ALLOCATION (col. 5 ± col. 6)	
			1	2	3	4	5	6	7	
		GENERAL SERVICE COST CENTERS								
1	0100	Old Capital Related Costs-Buildings and Fixtures								1
2	0200	Old Capital Related Costs-Movable Equipment								2
3	0300	New Capital Related Costs-Buildings and Fixtures								3
4	0400	New Capital Related Costs-Movable Equipment								4
5	0500	Employee Benefits								5
6	0600	Administrative and General								6
7	0700	Maintenance and Repairs								7
8	0800	Operation of Plant								8
9	0900	Laundry and Linen Service								9
10	1000	Housekeeping								10
11	1100	Dietary								11
12	1200	Cafeteria								12
13	1300	Maintenance of Personnel								13
14	1400	Nursing Administration								14
15	1500	Central Services and Supply								15
16	1600	Pharmacy								16
17	1700	Medical Records & Medical Records Library								17
18	1800	Social Service								18
19		Other General Service (specify)								19
20	2000	Nonphysician Anesthetists								20
21	2100	Nursing School								21
22	2200	Intern & Res. Service-Salary & Fringes (Approved)								22
23	2300	Intern & Res. Other Program Costs (Approved)								23
24	2400	Paramedical Ed. Program (specify)								24
		INPATIENT ROUTINE SERVICE COST CENTER								
25	2500	Adults and Pediatrics (General Routine Care)								25
26	2600	Intensive Care Unit								26
27	2700	Coronary Care Unit								27
28	2800	Burn Intensive Care Unit								28
29	2900	Surgical Intensive Care Unit								29
30		Other Special Care (specify)								30
31	3100	Subprovider (specify)								31
33	3300	Nursery								33
34	3400	Skilled Nursing Facility								34
35	3500	Nursing Facility								35
36	3600	Other Long Term Care								36

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Rev. 12 36-512.2

RECLASSIFICATION AND ADJUSTMENT OF TRIAL BALANCE OF EXPENSES | PROVIDER NO.: | PERIOD: FROM _____ TO _____ | WORKSHEET A

		COST CENTER DESCRIPTIONS (omit cents)	SALARIES	OTHER	TOTAL (col. 1 + col. 2)	RECLASSIFI-CATIONS	RECLASSIFIED TRIAL BALANCE (col. 3 ± col. 4)	ADJUSTMENTS	NET EXPENSES FOR ALLOCATION (col. 5 ± col. 6)	
			1	2	3	4	5	6	7	
		ANCILLARY SERVICE COST CENTERS								
37	3700	Operating Room								37
38	3800	Recovery Room								38
39	3900	Delivery Room and Labor Room								39
40	4000	Anesthesiology								40
41	4100	Radiology-Diagnostic								41
42	4200	Radiology-Therapeutic								42
43	4300	Radioisotope								43
44	4400	Laboratory								44
45	4500	PBP Clinical Laboratory Services-Program Only								45
46	4600	Whole Blood & Packed Red Blood Cells								46
47	4700	Blood Storing, Processing, & Trans.								47
48	4800	Intravenous Therapy								48
49	4900	Respiratory Therapy								49
50	5000	Physical Therapy								50
51	5100	Occupational Therapy								51
52	5200	Speech Pathology								52
53	5300	Electrocardiology								53
54	5400	Electroencephalography								54
55	5500	Medical Supplies Charged to Patients								55
55.30	*5530*	*Implantable Devices Charged to Patients*								*55.30*
56	5600	Drugs Charged to Patients								56
57	5700	Renal Dialysis								57
58	5800	ASC (Non-Distinct Part)								58
59		Other Ancillary (specify)								59
		OUTPATIENT SERVICE COST CENTERS								
60	6000	Clinic								60
61	6100	Emergency								61
62	6200	Observation Beds								62
63		Other Outpatient Service (specify)								63
		OTHER REIMBURSABLE COST CENTERS								
64	6400	Home Program Dialysis								64
65	6500	Ambulance Services								65
66	6600	Durable Medical Equipment-Rented								66
67	6700	Durable Medical Equipment-Sold								67
68		Other Reimbursable (specify)								68
69		Outpatient Rehabilitation Provider (specify)								69

RECLASSIFICATION AND ADJUSTMENT OF TRIAL BALANCE OF EXPENSES | PROVIDER NO.: _____ | PERIOD: FROM _____ TO _____ | WORKSHEET A

		COST CENTER DESCRIPTIONS (omit cents)	SALARIES	OTHER	TOTAL (col. 1 + col. 2)	RECLASSIFI-CATIONS	RECLASSIFIED TRIAL BALANCE (col. 3 ± col. 4)	ADJUSTMENTS	NET EXPENSES FOR ALLOCATION (col. 5 ± col. 6)	
			1	2	3	4	5	6	7	
70	7000	Intern-Resident Service (not appvd. tchng. prgm.)								70
71	7100	Home Health Agency								71
		SPECIAL PURPOSE COST CENTERS								
82	8200	Lung Acquisition								82
83	8300	Kidney Acquisition								83
84	8400	Liver Acquisition								84
85	8500	Heart Acquisition								85
86		Other Organ Acquisition (specify)								86
88	8800	Interest Expense							- 0 -	88
89	8900	Utilization Review-SNF							- 0 -	89
90	9000	Other Capital-Related Costs (see instructions)							- 0 -	90
92	9200	Ambulatory Surgical Center (Distinct Part)								92
93	9300	Hospice								93
94		Other Special Purpose (specify)								94
95		SUBTOTALS (sum of lines 1-94)								95
		NONREIMBURSABLE COST CENTERS								
96	9600	Gift, Flower, Coffee Shop, & Canteen								96
97	9700	Research								97
98	9800	Physicians' Private Offices								98
99	9900	Nonpaid Workers								99
100		Other Nonreimbursable (specify)								100
101		TOTAL (sum of lines 95-100)				- 0 -				101

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APPENDIX C

10-96	FORM CMS-2552-96	3690 (Cont.)
STATEMENT OF PATIENT REVENUES AND OPERATING REVENUES	PROVIDER NO.:	PERIOD: FROM _____ TO _____	WORKSHEET G-2, PARTS I & II

PART I - PATIENT REVENUES

	REVENUE CENTER	INPATIENT 1	OUTPATIENT 2	TOTAL 3	
	GENERAL INPATIENT ROUTINE CARE SERVICES				
1	Hospital				1
2	Subprovider				2
4	Swing bed - SNF				4
5	Swing bed - NF				5
6	Skilled nursing facility				6
7	Nursing facility				7
8	Other long term care				8
9	Total general inpatient care services (sum of lines 1-8)				9
	INTENSIVE CARE TYPE INPATIENT HOSPITAL SERVICES				
10	Intensive care unit				10
11	Coronary care unit				11
12	Burn intensive care unit				12
13	Surgical intensive care unit				13
14	Other special care (specify)				14
15	Total intensive care type inpatient hospital services (sum of of lines 10-14)				15
16	Total inpatient routine care services (sum of lines 9 and 15)				16
17	Ancillary services				17
18	Outpatient services				18
19	Home health agency				19
20	Ambulance				20
21	Outpatient rehabilitation providers				21
22	ASC				22
23	Hospice				23
24					24
25	Total patient revenues (sum of lines 16-24) (transfer column 3 to Wkst. G-3, line 1)				25

PART II - OPERATING EXPENSES

		1	2	
26	Operating expenses (per Wkst. A, column 3, line 101)			26
27	Add (specify)			27
28				28
29				29
30				30
31				31
32				32
33	Total additions (sum of lines 27-32)			33
34	Deduct (specify)			34
35				35
36				36
37				37
38				38
39	Total deductions (sum of lines 34-38)			39
40	Total operating expenses (sum of lines 26 and 33 minus line 39) (transfer to Wkst. G-3, line 4)			40

FORM CMS-2552-96 (9/96) (INSTRUCTIONS FOR THIS WORKSHEET ARE PUBLISHED IN CMS PUB. 15-II, SECTION 3640)

VITA

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